Volume 80 Number 2

POWER

POWER TOPICS CROSS-INDEX

STEAM GENERATION · POWER GENERATION · WATER POWER · DIESEL & GAS ENGINES · AIR CONDITIONING & HEATING · REFRIGERATION · PUMPS & COMPRESSORS · STEAM SERVICES · ELECTRICITY & ELEVATORS · INSTRUMENTS & CONTROL · PIPING SYSTEMS · MECHANICAL TRANSMISSION · POWER MISCELLANY

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FEBRUARY, 1936

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FRED LOW PASSES

• FRED LOW is gone. After long months of suffering he passed away January 22 at his home in Passaic, New Jersey, the city that has been his home for many years.

We knew that it must come, yet the event is an immeasurable shock. It is not merely that a great engineer and a great editor has gone to join his fathers. Such a tragedy would call for listing of honors and achievements, a final evaluation of things done. But there is something far more human than professional in our grief, because we all loved Fred Low. Thousands of men, of all ranks and conditions, loved him because he was their true and understanding friend. Fred was one of the rare great who also walk humbly, who abhor false pride and pretense, who without self-seeking are inevitably sought for the warm human feeling that shines in their eyes.

Fred Low is gone, but his spirit will abide with us. The memory of his words, written and spoken, will live. *Power*, built into an institution of service through the forty-eight years of his editorial leadership, will move on and on as the living monument of his practical vision. Enduring memories of Fred Low will be cherished by all who knew him.

To this man came innumerable honors and responsibilities. Their listing I shall leave to other hands. All that matters here is that our dear friend Low is gone. To his family, to his old associates on *Power*, to his innumerable intimates in America and abroad, I extend deepest sympathy in this great bereavement which we all share.

F. R. Low

Editor of *Power* 1888-1930, Editor Emeritus 1930-1936

1860—1936

FRED R. LOW

A Biographical Sketch

FRED R. LOW was born April 3, 1860, in Chelsea, Mass., a suburb of Boston. He attended public school until he was fourteen, then found a job in a Western Union telegraph office, where he learned both telegraphy and stenography.

After four years of this work he left it (in 1880) to spend two years as stenographer in court and general practice. In 1884 he took a position with the Boston *Journal of Commerce,* a textile paper with a power department. Here his first work was as secretary to the editor, but Low's interest was soon directed toward the steam-engineering problems of the textile industry.

To this field he was helped or pushed by his boss, Thomas Pray. One day, it is related, he walked into the office with a copy of *Barnaby Rudge* under his arm. Pray grabbed the book, slammed it into a corner and said: "Why the Hell don't you read something that will make you worth more around here?" As a substitute Pray handed him Zeuner's *Valve Gears.* This incident perhaps marked the turning point of a great career.

The eminent Fred Low of later years was always looked upon as a self-made man, and this was strictly true. His intimate knowledge of many phases of power engineering, and particularly of boilers and steam engines, was built upon a meagre foundation of formal training that carried him only through grammar school. He was fourteen when serious illness forced him to leave school.

After formal education ceased, he made himself an engineer and a man of culture in the best sense. He did it by reading and studying, by playing around in power plants, and perhaps most important of all, by working always with men, helping them to solve their technical problems.

These early years of basic study and engineering experience were entwined with a love story of romantic and enduring quality. While Adeline Giles was still in high school, she and Fred Low struggled with her algebra together. Later (in 1881) they married—for life. Until death brought separation, "Mother Low"—quiet little woman, utterly devoted, feminine and lovable—stood at his side. Through the whole of Fred Low's life, from the day of their marriage, the two were inseparable. They viewed themselves, and their friends viewed them, as the halves of a single picture.

Going back to these early days with the *Journal of Commerce,* Mr. Low had a friend from Worcester Polytechnic, Frank M. Clark, and learned from him the high points of his technology.

In 1882 the N.A.S.E. was started. Mr. Low joined in 1885, attended meetings and swapped theory for facts with his many friends there. It was a mutually helpful contact which he never relinquished.

Upon the resignation of Pray in 1886, Mr. Low was made editor of the steam-engineering section of the *Journal of Commerce* and threw all of his enthusiasm into the problems of the steam operating men. The steam-engine indicator was coming into use in the various mills. Mr. Low wrote articles telling the old-timers how to use the new device. He went into the mills and showed them the way to indicate and test their engines, how to line up shafting and work out power problems.

Each day he rode to and from work on the Chelsea-Boston ferry boat, mostly down in the engineroom talking with the engineer and the fireman and taking a hand, now and then, in operating the boilers and engines. He formed a partnership with his old friend, Frank M. Clark, the Clark & Low Machine Company. With Clark he invented an improved steam-engine indicator, a boiler-tube cleaner, an elevator controller and a rotary steam engine.

In 1886 Mr. Low joined the A.S.M.E., marking the beginning of his second life-long engineering affiliation. The third, his connection with *Power,* was still in the offing, but the seed had been planted.

For *Power,* like Fred Low, traces its engineering lineage back to Boston's old *Journal of Commerce.*

In 1882 E. P. Harris and H. M. Swetland, then advertising salesmen on the *Journal,* talked about a new paper to be devoted exclusively to power plants. From this discussion eventually grew *Power;* the first issue appeared in November, 1884, 52 years ago. The new publication incorporated *Steam,* which had been started two years earlier in Chicago and had been a vital factor in the founding of the National Association of Stationary Engineers in 1882.

Soon Swetland and his young former pupil, James H. McGraw, were in active command of *Power* on the business end.

In the brief period from 1884 to 1888, the magazine had five successive editors. Grimshaw, Fowler, Risteen, VanWinkle and Low, but Mr. Low broke this precedent of rapid change by a stay of nearly half a century.

In 1888 he left the *Journal of Commerce* to become

mechanical editor of *Power,* his title being changed shortly thereafter to editor. His connection with *Power* was continuous until his death. His service as active editor extended 42 years, to Jan. 1, 1930. Thereafter he was editor emeritus.

Thus Mr. Low, far more than any other one man, molded *Power's* policies and services and was, in turn, molded by them. The magazine was the center of his activities, but they extended beyond it in many directions. He continued his close association with the N.A.S.E. (later N.A.P.E.) and always maintained his devotion to the interest of the practical operating man, while broadening *Power* to serve, as well, the interests of the consultant and plant designer.

Mr. Low's work with the A.S.M.E. was extensive and of far-reaching importance. Year after year he labored at arduous committee jobs, with no thought of recompense other than the pleasure of cooperating with other public-spirited engineers to advance the society and the profession and to set up safe and acceptable standards for the construction and testing of power equipment. But other rewards came inevitably. He had always valued friendship and he won it in abundance. With it came many honors, marking his acceptance as a distinguished leader.

This work and these honors will be presented in briefest outline. In 1905, Mr. Low was made chairman of the newly established Gas Power Section of the A.S.M.E., its first professional division. From 1912 to 1917 he was a member of the Publications Committee. He helped organize the Fuels Division and was chairman of its executive committee from 1922 to 1925. From 1917 to his death he was a member of the famous Boiler Code Committee and since 1925 its chairman. He actively supported the work of the American Uniform Boiler Law Society.

From 1918 to his death, Mr. Low rendered outstanding service as chairman of the Power Test Codes Committee. In 1922-23, he was chairman of the Executive Committee of the Fuels Division, and in 1918 vice-president of the Society.

The year 1924 stands out in Fred Low's life as the peak of his achievements, the winning of ultimate recognition. In 1924 Rensselaer Polytechnic Institute made him "Doctor Low" (honorary Doctor of Engineering) but his friends still called him Fred—the man submerged the degree. A.S.M.E. made him president in 1924. As its representative he attended the World Power Conference in London, where he was made an honorary member of the Institution of Mechanical Engineers of Great Britain, there being at that time only twelve such members.

Two other periods are worth noting in passing, one devoted to book authorship and one to political activity in his home town, Passaic.

Mr. Low published four books: "The Steam Engine Indicator" (1898) and in 1906 "Power Cathechism," "Condensers," "The Compound Engine."

His political career, which did not interrupt his editorship of *Power,* extended from 1901 to 1909, all in Passaic. Councilman in 1901-03, he served as President of the Council in 1905-06. In 1908, after a hot contest, he became Mayor of Passaic.

This by no means exhausts the list of his important associations, activities and honors. Mr. Low was an honorary member of the National Association of Practical Refrigerating Engineers, the National Board of Boiler and Pressure Vessel Inspectors and the American Boiler Manufacturers Association. He was a member of Council of the Newcomen Society and a member of the Vereines Deutscher Ingenieure, the Engineers' Club of New York, Yountakah Country Club (Nutley, N. J.), Plymouth, N. H. Golf Club, and the Engineers' Club of Boston. He was past president of the Passaic City Club.

Mr. Low was a 32nd Degree Mason and Shriner, a member of Passaic Lodge No. 67, F. & A.M., Centennial Chapter No. 34, R.A.M., Washington Commandery K.T. No. 21, Salaam Temple Mystic Shrine. He also belonged to the B.P.O.E., Passaic No. 387.

In July, 1928, *Power,* without the knowledge of Fred Low, who was vacationing at his New Hampshire farm in Plymouth, marked his 40th Anniversary with the magazine in a special section which included notes of appreciation from many of the world's well-known engineers.

On January 1, 1930, after 42 years of continuous service, he retired from the active editorship at the age of 70. As Editor Emeritus, Mr. Low maintained a close interest in the affairs of *Power* and those of the A.S.M.E,. particularly the Power Test Codes Committee and the Boiler Code Committee.

He had hoped to spend the years of retirement comfortably at his Plymouth, N. H., farm, and fishing in Florida with old cronies, but fate ruled otherwise. Physical ills gradually crept over him until, particularly during the last four years, he was confined almost constantly to his home.

During years of critical illness, while friends inquired constantly for him, he suffered and weakened, fighting the inevitable end. But his friends will be happy to know that in his losing fight he was always Fred Low. To the very last his keen sense of humor and of human values rose to the surface again and again through his pain. His mind slowed its tempo but never lost its true sense of values. He knew the end was coming and faced it.

Mr.Low is survived by his wife, Adeline Giles Low, his sister Mrs. C. E. Hersom and by four children, fourteen grandchildren and two great-grandchildren.

APPRECIATIONS

FRED LOW, friend, preceptor, interpreter and citizen, endeared himself to all with whom he came in contact. His sound common sense, his deep interest in the present and his hope for the future appealed most strongly to his contemporaries and especially to those who were not gifted with his sanguine disposition. His personal friendships were wide and all embracing, but the thing which drew us most closely together was his catholic taste and interest in all manner of subjects, whether connected with engineering, his chosen field, economics, or the other sciences; and the broad sympathy which showed in every act and word. We have lost a good friend who will be long remembered.

GEO. A. ORROK,
Consulting Engineer,
New York, N. Y.

AS FRED LOW'S cheerful yet hopeless struggle against the inevitable has ended, through sheer physical exhaustion, many tender memories arise regarding that lovable character so long and so intimately associated with that great engineering institution of which he was president, and so well known to that great public, the makers and users of power.

In this latter capacity he contributed as few have been able to do in the selection and regimentation of information, that makes it most valuable and available for the great army of readers who regarded his steady flow of engineering information and whimsical philosophy as gospel. Fred Low reached the great throng of power producers as few others ever could, and as a high executive in the councils of The American Society of Mechanical Engineers, he saw eye to eye with those industrial leaders who were concerned in the larger aspects of power production and use. Thus he encompassed the whole range of those concerned in that branch of industry.

Fred Low is gone, but such was his strong, lovely and helpful character that his going leaves a warmth and afterglow that remains with us as a benediction.

W. L. ABBOTT,
Chief Operating Engr.,
Commonwealth Edison Co.,
Chicago, Ill.

I HAVE known our mutual friend, Fred Low, for the past thirty-five years, have been associated with him in many events and affairs of the N.A.P.E. He was ever ready when called upon to further the interest of the association he loved so well.

Passaic Association No. 11 of New Jersey, of which he is a member, will feel his loss keenly, as all of his friends who knew him well will.

During the time that he served as Editor of *Power* he served for a number of years as a member of the Advisory Board of the New York Power Show. I had the opportunity during my membership of this board to know him well, and I can truthfully say Fred Low was one of God's noble men.

FRED FELDERMAN
Past National President, N.A.P.E.
Jamaica, N. Y.

SINCE I have had the most friendly relations with Fred Low for thirty years, I have been in a position to appreciate his thorough knowledge of all matters pertaining to motive power.

Fred Low was a hard worker. He devoted the best of his life and energy to the development of *Power,* and has contributed to make of it the most popular and instructive periodical and, by the very fact, has promoted the knowledge of practical science of mechanics among students and engineers. The subjects he dealt with were always clear and comprehensive and were published to the greatest benefit of the readers because they were written more with the idea of being instructive than with the view of showing the author's own knowledge.

Moreover, Low was a kind and devoted friend whose decease leaves a great gap among all those who did approach him; they will feel that in spite of his age, his fine career has been too short.

As one of my best American friends, his death affects me deeply, and I sincerely condole the family of my old friend Low as well as the directors of *Power.*

R. E. MATHOT
Vice-President of the International
Federation of Consulting Engineers,
Brussels, Belgium

THERE are relatively few men whose passing has caused as general regret and sorrow as that of F. R. Low. To be of real help to all concerned with power plant problems was one of his most ardent desires. How well he attained this end is amply evidenced by the standing of *Power,* the periodical he largely made.

As chairman of both the Boiler Code Committee and the Power Test Code Committee of the American Society of Mechanical Engineers he guided the deliberations of those bodies with excellent judgment and diplomacy.

E. R. FISH
Chief Engineer, Boiler Division,
Hartford Steam Boiler Inspection &
Insurance Co.

FRED LOW'S record of distinguished service to The American Society of Mechanical Engineers reveals a generous contribution of time and effort to the advancement of his profession. He served as chairman of the Power Test Codes from 1918 and as chairman of the Boiler Code Committee from 1925. Until his death, although illness made his active participation impracticable, a grateful group of coworkers continued to honor him by retaining him in these offices. He was always available for committee work and because of his fairness, tolerance and sound judgment, his services as chairman of special committees were much sought.

As president, his leadership was enhanced by the wide circle of friends which his capacity for friendship and his lifelong services as Editor of *Power* provided and was marked by his sincerity and high ideals. During his presidency high honors came to him. He bore them with modesty.

C. E. DAVIES
Secretary,
The American Society of Mechanical
Engineers

THE death of Fred R. Low is a great loss to his many, many friends throughout the engineering world. Few, if any, men have been as universally admired, respected and loved as was he. It was a privilege and a joy to have known him.

A. G. PRATT
President,
The Babcock & Wilcox Company

THE memorials of most men are built of cold stone, brick and steel, but Fred R. Low, self-made power engineer, wise counselor and friendly philosopher, leaves his memorial builded on the abiding gratitude of those power engineers who received from his eloquent pen the inspiration to keep them from becoming "stuck on center."

BEN BENTON,
Chillicothe, Ohio

IN THE death of Dr. Frederick Rollins Low, the engineering profession has lost a man who was consistently thorough and sound in all matters that he handled. He had a kindly and helpful disposition, and was a staunch friend to all who knew him.

JAMES PARTINGTON,
Manager, Engineering Department,
American Locomotive Company,
New York, N. Y.

IN THE passing of Fred Low the engineering world has lost a stimulating personality and an outstanding member of the engineering profession. As an editor, writer, and prominent member of the American Society of Mechanical Engineers his constructive influence will long be remembered. To those of us who for many years enjoyed working with him it is a source of extreme regret that his labors are ended. Genial and companion-

able, it was always a pleasure to work with him. He will be mourned by a host of friends.

The work of such a man is never lost. He will be remembered mostly as the great Editor of *Power*. Under his leadership this important magazine first assumed the commanding position it still holds. Truly in this case the publication is the "lengthened shadow of a great man." His contributions were great and lasting. A great editor and an honorable and genial gentleman has completed his labors, but his memory will long remain and his works will endure.

DEXTER S. KIMBALL,
Dean of College of Engineering,
Cornell University,
Ithaca, N. Y.

IN FRED LOW'S death the world has lost something that probably will never be replaced. Fred combined the composites of a good engineer, a good diplomat, a good executive, and a good friend under the one entity where each activity co-ordinated and supplemented the others. Among all his qualifications I think his diplomatic ability is the one that stands out most strongly in my mind. This was shown very strikingly in his work as Editor of *Power*, as president of the American Society of Mechanical Engineers, and as chairman of some of the very important A.S.M.E. committees, such as the Power Test Codes and the Boiler Code. These various engineering society activities I have just enumerated called for good engineering training and good sound judgment, and above all, great diplomatic ability. Fred had and exercised all these qualities, and as I was very close to all these activities at their critical stage, I can appreciate more fully than many the wonderful work which Fred did for the Society and for engineers in general. The world is better for his having been with us, and it will be a long time before the vacancy caused by his death will be filled.

I. E. MOULTROP
Chief Engr., Supt. of Constr.,
Edison Electric Illuminating Co. of Boston
Boston, Mass.

HIS activities as an editor, engineer, educator, counselor and friend have ceased—the curtain has been gently lowered. He was a loving husband, father and faithful friend.

He made for himself a place high up on the scroll of achievements, and his accomplishments as a scholar and friend will live long in the memory and hearts of men. He has done his full share in making the world better for his having lived. This, Frederick Rollins Low, is my humble tribute to you—my friend.

CHAS. E. GORTON
New York, N. Y.

FRED LOW was interested only in facts. My earliest contact with him was in ferreting out the facts about the Carroll CO_2 engine in Boston about 25 years ago. The facts were found out, printed in *Power*, and a fake was ended by the Post Office Inspection Department.

Mr. Low's words of advice and encouragement to me as a young engineer starting in business, were of great inspiration and assistance.

My last visit to his bedside Aug. 31, 1935, found him almost helpless physically, but still keenly interested in the welfare of others. The engineering profession has lost a most devoted friend and counselor.

E. G. BAILEY,
Vice-President,
The Babcock & Wilcox Co.

EXCEPT for Mr. Low himself, I am the only living man who has been associated with *Power* continuously since March, 1887, when Fred Low first came to *Power* from the Boston Journal of Commerce in August, 1888. This means that I have known him 47 years. To me he has been a constant inspiration as I have watched him through the years, giving his utmost to the practical service of his fellow men, particularly his fellow engineers.

CHESTER W. DIBBLE
Assistant Manager, "Power"

ON BEHALF of the officers and membership of the National Association of Power Engineers, Inc., I desire to express our sincere regrets at your loss in the passing away of our friend and brother, Fred R. Low.

The engineers of the United States and the world will miss him; he was a shining light in the engineering world. His counsel and advice was always convincing; his writings and work will always be a monument to his name; he was a leader in his profession. His friendship covered a great field and his service to the many organizations in which he always took an active part, and especially ours, was most sincere and deeply appreciated.

His loyalty to all he was connected with can never be equaled. To his immediate family and closest friends we can only sincerely, deeply and affectionately sympathize in this, their great hour of bereavement.

F. W. RAVEN
National Secretary,
National Association of Power
Engineers, Inc.

MY FRIENDSHIP with Fred R. Low started in 1906 when he spent a day looking over the new Allis-Chalmers turbines in the New York district which were being put into operation under my direction. Later on, he induced me to write my first articles for *Power*, covering steam turbines and experiences with Canadian coals. A trip together in Europe in 1910 served still further to develop our acquaintance and to give me a better appreciation of the likeable character and true ability of Mr. Low.

My many contacts with him since those far-off days has further demonstrated the value of Fred Low's friendship. He has often aided me with kindly advice and thereby proved a helpful councillor. Mr. Low had a keen engineering mind and had that rare gift of truly appraising the value of new inventions and developments. Under his direction, *Power* became an authority on all matters dealing with the development of mechanical energy. His long and untiring services to the profession have yielded tangible results in the A.S.M.E. boiler codes, test codes and other valuable contributions. Mr. Low's professional idealism won for him the honor and admiration of all friends and associates. His genial manner and ready smile made him many friends all over the country, and these will miss him at future gatherings.

Steadfast friend, able engineer and honored leader, we mourn your passing!

A. G. CHRISTIE,
Prof. of Mechanical Engineering,
Johns Hopkins University,
Baltimore, Md.

FOR almost 35 years I have known Fred Low, first by correspondence and in later years meeting him personally at many of the Annal Conventions of the N.A.P.E.

To me the outstanding characteristic of Fred Low was his keen sense of what was right and just. He fully believed that truth was indeed a Divine attribute, and throughout his long career as Editor of *Power* there was ample evidence of this quality. I deem it a great privilege to be among the many known by Fred Low as friends.

ROBERT CRAIG
Los Angeles, Calif.

I FIRST met Fred Low in the old *Power* office in the World Building in about 1890. Then, as always, he was very cordial and encouraging to a young writer. I was closely associated with him for many years and found him most human, considerate and always keen and stimulating. He leaves pleasant memories in the hearts of his many friends.

FRED H. COLVIN,
"American Machinist"

FRED LOW was beloved by his co-workers and had a rare quality of tact and humanity that endeared him to all. Those of use who knew him well can still hear his kindly voice. He was all that was good and wholesome, ever willing to lend a helping hand and to hearten those about him. He will be mourned as a true and trusted friend who added much to our life and happiness.

DR. D. S. JACOBUS
The Babcock & Wilcox Co.
New York, N. Y.

WHEN confronted with the knowledge of the passing of a friend, we engineers in particular are at a loss to express our feelings adequately, especially when one has been as near and dear to us and to our profession as has Fred Low. From the early days of my technical training and engineering career, his name stands out as a leader and an example in and to his profession. Later in life when I knew him personally my earlier impressions were confirmed, and still later when I was privileged to work with him on various tech-

nical committees, I came into a full realization of the character of the man. One had but to read his personal page in *Power* to gain an insight into his gentle and kindly nature and the depth and wisdom of his mind. Throughout his life we and our (and his) profession have been uppermost in his mind. Only a few days before the end I talked with a friend in common who has known Fred Low intimately throughout his life and who had seen him frequently during his last days. This friend told me that Fred Low's talk to the last was constantly of his friends and the work that was nearest his heart, the Boiler Code Committee.

Honored nationally and internationally he needs nothing that we can say to add lustre to his name. With this knowledge and appreciation of the man I pay sorrowful and humble tribute to his passing with a full appreciation of the honor that has been mine to know and work with him.

FRANK S. CLARK,
Boston, Mass.

WE MET at the first World Power Conference, held in London, June 30 to July 12, 1924, which he attended as President of the American Society of Mechanical Engineers. He read a paper on "The Social Aspect of Power Development." At the meeting when Dr. D. S. Jacobus read a notable paper on "High-Pressure Boilers," I was happily seated next to Mr. Low, and seated at the other side of him was George A. Orrok (consulting engineer to the New York Edison Company). Soon after the discussion commenced, the latter commented upon the high steam pressures produced by Jacob Perkins; and as I had had some two years experience on experimental high-pressure boilers (and their construction) and engines designed by Loftus Perkins (Jacob's grandson) in the later seventies, I ventured to address the meeting on some points of historical interest, which very much interested Mr. Low, in particular.

And year by year since that happy time we have at least exchanged Christmas greetings, his being most artistic and beautifully worded, conveying to us never to be forgotten good wishes.

PROF. HENRY J. SPOONER,
London, England

THE death of Fred Low is a great loss to his many friends and power engineers. His understanding of their every-day problems could be found in his editorials, and he will long be remembered by the members of the National Association of Power Engineers.

P. F. CASSIDY
State Deputy President, N.A.P.E.
Floral Park, N. Y.

THE friendship of Fred Low was not a fleeting gesture. Once gained, it expanded and grew with the passage of time in the depth and warmth of his affection.

VINCENT M. FROST
Mechanical Engineer,
Public Service Electric & Gas Co.,
Newark, N. J.

THE passing of Fred Low removed from our midst an exemplary character whose integrity moulded the career of many young engineers, and his excellent editorials in *Power* will certainly have a lasting influence. The engineering profession has sustained a great loss.

DUDLEY G. KIMBALL,
Past National President,
National Association of Power Engineers,
Boston, Mass.

THE passing on to the Great Beyond of our very old and loved friend, Frederick R. Low, occasions us profoundest regrets. The writer was fortunate in the very intimate contact which existed between us for over forty years, during which period the sterling qualities and the high ideals of Fred was constantly exemplified. His helpful suggestions as to preparing our advertising copy for *Power* in our younger days enabled us thus to create a market for our products through the use of certain unusual and impressive copy, some of which we are using to this day.

On such occasions as this, one realizes how weak and fruitless words are. We cannot alter everlasting laws nor stop the timepiece of Eternity which strikes for each one his hour to fall asleep. Our loved friends come, they go and as they pass on, we can only reflect upon the offerings they have made during their lives which fixes their memory and places them among the crowding recollections of receding years.

PAUL B. HUYETTE,
President, Paul B. Huyette Co., Inc.,
Philadelphia, Pa.

I HAVE known Mr. Low for about 35 years and always considered it a great honor to be counted one of his friends, and I am sure many friends all over the country will be very much grieved to hear of his passing, and the engineering profession will have lost a great man, one who was always ready to render any assistance possible to help those who were in need of such help, and the N.A.P.E. will have lost one of its pioneers who did his share to further the interests of the association and its members at all times. I personally cannot adequately express my deep sorrow at his passing.

W. J. REYNOLDS,
Office of U. S. Deputy,
National Association of Power Engrs., Inc.,
Hoboken, N. J.

THE news of the death of my old friend, Fred Low, brought back to my memory the many years which he so efficiently served as Editor of *Power*, and I think we all remember the many technical power-plant problems which he handled so ably for us.

S. B. FORSE,
Pittsburgh, Pa.

IT IS with keen regret that I learn of the going of Fred Low. I knew Fred when he became Editor of *Power* and I have admired and loved him always. He met me so many times at luncheon at the Engineers' Club, and it was such a treat to listen to his experiences, his stories, his hopes and plans for building up *Power*. He was devoted to his work. He helped many thousands to understand the practice and principles of their work. Someone will tell of his life and his work—it was all so helpful to others—but no one can tell to others why we who knew him loved him so. His last years have been so sad, he deserved to enjoy them more. It must be all for the best but I do hate to lose him.

L. P. BRECKENRIDGE
Professor Emeritus of Mechanical Engineering, Yale University

MY ACQUAINTANCE with Fred Low began some twenty-five years or more ago when he was actively the Editor of *Power*, and I in charge of the design of steam turbines for the Westinghouse Co. Frequently Fred Low would be looking for "copy" and drawings of latest designs of machines for publication. Because of his persuasiveness and pleasing personality, he invariably got just what he wanted, and I venture the opinion that no editor of a technical magazine was as much "persona grata" in engineering organizations all over the country as was Fred Low.

I later became more closely associated with him in serving under his chairmanship of the Power Test Codes Committee of the A.S.M.E. and under his directorship of the U. S. Secretariat for Prime Movers of the International Electrotechnical Commission.

His enthusiasm and wise guidance made the work a pleasure and produced results. The work has been progressing successfully during his long illness, but his spirit still does and will continue to prevail.

FRANCIS HODGKINSON
Westinghouse Elec. & Mfg. Co.
Philadelphia, Pa.

IT SEEMS to be that one of life's severest penalties that such afflictions should have to be endured after an active life spent largely to benefit others, and particularly as this comes usually at a time when the mental stimulus of further achievement is not available to bolster up one's courage. Fred Low's fortitude under these circumstances has been amazing.

I valued highly his kindly and unassuming friendship; the passing of Fred Low removes another prominent name from the list of those whose untiring efforts gave us the present advanced state of engineering.

FRANK L. FAIRBANKS
Wakefield, Mass.

I KNEW Fred Low for some sixteen years, and through all that time learned to regard him with increasing respect and affection.

For some years I knew him only as chairman of the Power Test Codes Committee of the American Society of Mechanical Engineers. In directing the discussion of controversial questions, he showed exceptional skill. His good humor eased the tension of heated debate, and his good sense broke

many a deadlock. He showed himself a capable leader, admired and respected by all.

Then for three years I had the pleasure of working under his direction on the editorial staff of *Power*. His insistence upon truth and upon its statement in convincing and interesting fashion did much to make the magazine what it is. His ability to write forcefully and clearly, and his impatience with slipshod work both inspired and drove his associates to their best efforts. His pleasant reproofs of verbosity were amusing and instructive. "What is the difference," he would say, "between 'tight' and 'absolutely tight'?" He had a thoroughly practical prescription for the man who tries to find an effective beginning for an article by dreaming about the subject. The way to write, he often said, is to take a pencil and begin to put words on paper. Before long the material takes shape, nad a good beginning has been accomplished.

His wide acquaintance was amazing. He seemed to know everybody in the field and what was being done everywhere. He was a champion of new ideas. And he was fearless in the face of criticism.

On several occasions it was my delight to be entertained in his summer home in New Hampshire, and there I saw him as the genial host, happy among his family and friends. Children seemed especially to find the way to his heart. His days were spent happily in caring for his property and in enjoying it. Local residents who carried out his plans found him an exacting but admirable taskmaster, and they seemed to work for him with an eagerness to please that it was good to see. And from hints here and there I gathered that they found him a real friend in time of need. On one occasion I enjoyed the rare treat of playing a round of golf with Fred Low, his son, and his grandson, and it was both amusing and touching to see the fine spirit of comradeship between the three generations. As evening came, we would often sit on the broad unroofed porch and take our turn looking through his prized telescope at the stars, with which he was so familiar and in which he was keenly interested. It was a happy household, and the many guests who came and went carried away with them a feeling that they had been on a mountain top, perhaps not geographically, but certainly in the art of living.

During these last sad years, the thought of Fred Low confined to his bed has been a real burden. Always a lover of active out-of-door life, always a vigorous positive personality, it seems peculiarly painful that he had to suffer so prolonged and so complete a separation from all that made life worth while for him. But the memory of the man goes back of this trying period. One recalls him as a born leader, a staunch fighter, a perfectly fair and open opponent, a faithful friend, a true gentleman.

C. HAROLD BERRY
Prof. of Mechanical Engineering,
Harvard University,
Cambridge, Mass.

PERSONALLY, I wish in my small way to pay tribute to his memory. I remember him well, and had the pleasure and honor of his acquaintance for more than 30 years. Fred Low's work is finished. He will be missed particularly by the engineering profession, who valued his keen perception. He gave freely of his time and his talent to the problems that faced us from day to day in our work. He finished in the full flush of his power and his usefulness.

All of us will regret his passing and will always remember his distinguished career as one of complete devotion to his ideals of duty.

JOHN CALAHAN,
Past National President,
National Association of Power Engineers,
Jersey City, N. J.

IN THE death of Fred Low the engineering profession has suffered a great loss. While he has passed from our midst, the evidence of his work will long remain with us, for he built well the foundation of our modern mechanical-engineering journals.

When Mr. Low was forced to give up active duty, the operating engineers lost a real friend who was an inspiration to their entire professions, for their interests were his, for they were guided and instructed by this fine gentleman. I shall always feel that one reward I have for engaging in engineering work is that it enabled me to have the friendship of Fred Low, a memory I shall always cherish.

JOHN H. LAWRENCE,
Interborough Rapid Transit Co.,
New York, N. Y.

FOR nearly half a century Fred Low was the voice and apostle of power. The period in which he served the industry as editor was one of extraordinary change and expansion. It was his duty to keep his readers abreast of these changes and to prepare them for the expansion.

His own power was that of his personality. From the men he met—operators, designers, engineers, teachers, and scientists—he learned the difficult lessons of human nature. How well these lessons were learned and what value they were to him, as a leader of men, have had abundant proof in his success as chairman of the Power Test Code Committee of The American Society of Mechanical Engineers. Tolerance, understanding, a spirit of sympathy for all reasonable points of view, so necessary in conferences where conflicting interests and opinions threaten to destroy the fruits of cooperative effort, were his in full measure.

GEORGE A. STETSON
Editor,
"Mechanical Engineering"

IN THE passing of Fred R. Low, the engineering fraternity has lost a valued friend and a wise counselor. Those who knew him personally loved him for his manly qualities and his marked ability as a writer on engineering subjects. Through his many years as Editor of *Power* he kept to the front in all improvements in the power-plant field, and we must all agree they were numerous as we look back to the status of steam engineering. His attendance at all gatherings of engineers for so many years was a treat to his old friends to greet him. His election to the presidency of the American Society of Mechanical Engineers was a fitting tribute to one who had lent his talents to the greater development of engineering projects. Now that he has gone, it leaves a void that is hard to fill. May he rest in peace, and reap the reward his service to mankind on this earth deserves in a future life.

T. N. KELSEY,
Lowell, Mass.

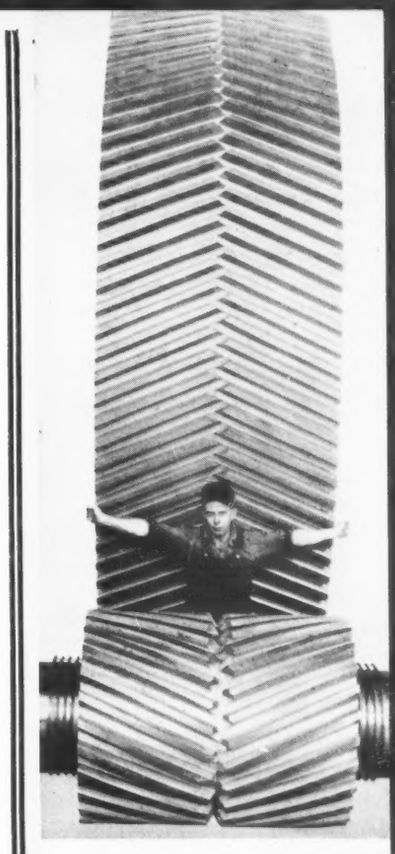
IT HAS been my good fortune to have been associated with Fred for a period of over a quarter of a century—his work, and his methods of working, were a constant inspiration to me—and his wise personal counsel has had a marked bearing on my life. It will always be a source of great pride to me that he permitted me to call him my friend.

WM. BUXMAN
Manager,
"Engineering News-Record"

Mr. Low died just as POWER for February went to press. Therefore, no reference to his death will be found in the following pages

POWER

A McGraw-Hill Publication—Established 1884
PHILIP W. SWAIN, *Editor*



HARNESS FOR POWER

SKILL in application, as well as in generation, is the measure of the power engineer in industry. Undelivered power is worth nothing. All grant this truth, but in this "age of electricity" some forget that mechanical transmission steps into every power picture, whether the prime source be mechanical or electrical. Electricity shifts the location of the mechanical steps, but cannot eliminate them. Even "direct connection" involves a coupling—basic mechanical-transmission element.

But more often than not, direct connection isn't used, or is an engineering mistake if it is. Today even the individual-drive enthusiasts agree that the right motor plus the right transmission is generally better, cheaper, more compact and efficient than a motor whose design has been manhandled for direct mating to the driven machine. For motors, like greyhounds, are built for speed—weigh and cost too much if they aren't—while the average production machine or power-plant auxiliary best runs slower.

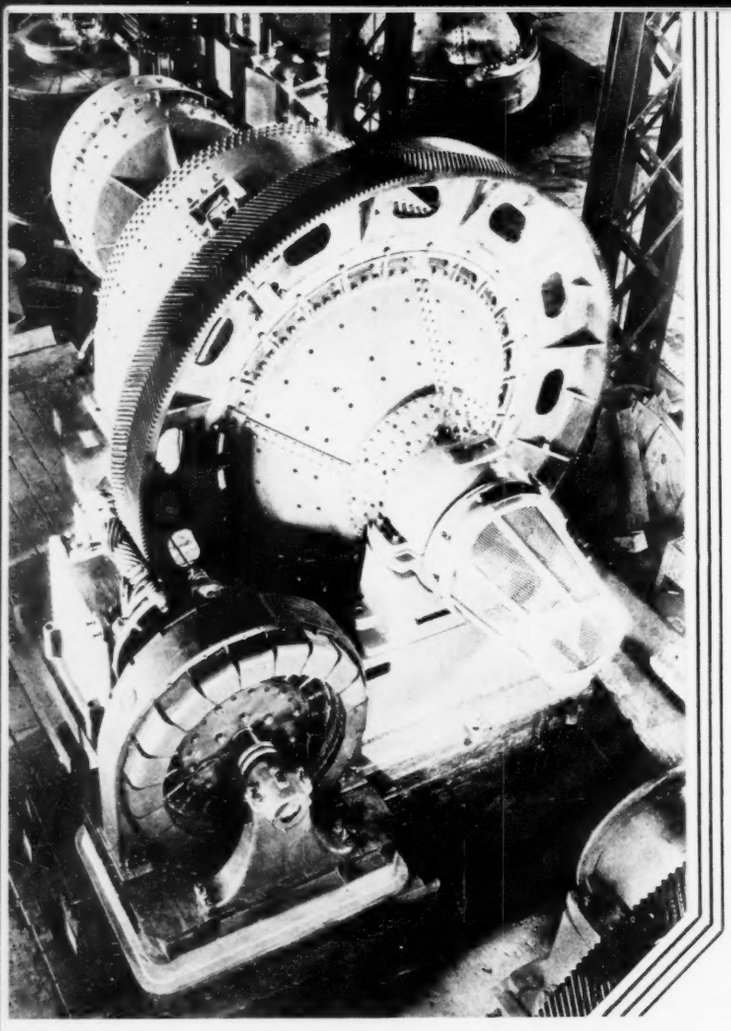
Where fans, pumps, grinders, generators, naturally run at or near motor or turbine speed, direct connection is fine, but often the motor must run much faster than the driven machine or else somebody will pay plenty. The simple fact is that a driving machine is one thing and a driven is another, and if the twain ever meet on a speed par it is either a design blunder or an act of God. This, of course, applies to turbines and engines as well as motors.

Today designers do not so often stretch a point in machine speeds for the sake of direct connection. The reason is clear—the enormous recent improvement in transmissions and the availability of new designs and better materials for every need.

Nothing in transmission is as it used to be. Modern belt drives grip better, last longer, withstand grit, oil, water and acid, run well on short centers, twist in any desired fashion. Gears are smoother, quieter, made of steels that stand the gaff. Speed reducers and gearmotors are available in endless variety for any power, any reduction, any relative position of shafts. Chains and sprockets are precise mechanisms. Modern group drive adds low operating cost and adaptability to the low first cost of belts and shafting. Almost overnight the possible applications of group drive have increased and the possible ways of doing a given transmission job have multiplied.

Fine, but how about the engineer? Already weighed down with the need for new knowledge of boilers, engines, turbines, air conditioning and so on, he faces the necessity of relearning all he once knew about transmission. Where shall he find the time in his busy day?

Sensing this pressing need of most of its readers, *Power* presents the boiled-down essence of modern mechanical transmission in the fifteen pages that follow. Not everything that could be said, of course, but the main points, the practical time-and-dollar-saving points, the steps that every engineer must take before he finally pins himself down to a single page in a single one of hundreds of transmission-equipment catalogs.



Gearing a 400-hp. synchronous motor to a ball mill provides a slow-speed driver and p.f. correction

MECHANICAL TRANSMISSION EQUIPMENT TODAY

By F. A. Annett
Associate Editor

Belts, chains, gears, clutches, couplings and shafting of two decades ago have come of age as an amazing array of equipment tailored and groomed for today's exacting drives. This 16-page section is the power engineer's roadmap to power highways of 1936

WITHOUT a harness a horse can't pull a wagon, and without a driver he won't pull it in the right direction. Without a transmission "harness" a prime mover or motor can't pull its load either, and without some kind of controlling element, it won't pull the load right. The pulling element may be electric motor, internal-combustion engine, steam engine or turbine, waterwheel or a combination. The "harness" may be coupling, clutch, gear, chain, belt, rope, speed-changing device, or several of them in combination, for individual or group drive. The controlling device may vary from a low-cost simple, starting switch to an expensive and complicated controller for an electric motor. It is the power engineer's frequent responsibility to select the proper combination of "horse," "harness" and "driver."

Modern prime movers are most often direct- or gear-connected to their loads. When connected by gear, chain or belt they become more or less specialized applications, discussed more completely in the part of this section devoted to the particular mechanical transmission concerned. The next three pages, therefore, deal chiefly with electric-motor drives, which utilize the greatest number, as well as the greatest variety, of mechanical-transmission units. Many pointers given, however, are also applicable to prime movers similarly harnessed.

Certain classes of driven equipment have speeds corresponding closely with those of medium- or high-speed motors of correct rating for the drive. Here a coupling or clutch is usually the most economical harness. Where power costs are more when power factor drops below a contract minimum, a slow-speed, direct-connected synchronous motor may be better than a high-speed induction motor with some form of speed reducer.

Outside those applications where direct drive is most suitable or economical, is a large field in which a high-speed motor and a transmission unit is more satisfactory. Often it is practically impossible to build motors for speeds low, or high enough for direct connection, so some form of speed reducer, or increaser, must be placed between motor and load. Other loads demand speed ranges that cannot be obtained electrically, or at least cannot be obtained economically. The answer here is a simple speed reducer and variable-speed transmission. In other applications, group drive of several machines from one high-speed motor is best.

Speeds at which a.-c. motors run are fixed by circuit frequency and number of poles in the motor, Table I shows synchronous speeds for 25- and 60-cycle motors. Maximum speed is 1,500 r.p.m. for 25-cycle motors; for 60-cycle motors there is no speed choice between 3,600 and 1,800 r.p.m. Driven-machine speed must be made to match motor speed to permit direct connection, which may not be suitable. Therefore it may be more economical to design the driven unit for a preferred speed and connect the motor by a speed reducer or increaser.

Where driven-machine speed is slow, driving-unit

Table I—Synchronous Speeds of A.C. Motors

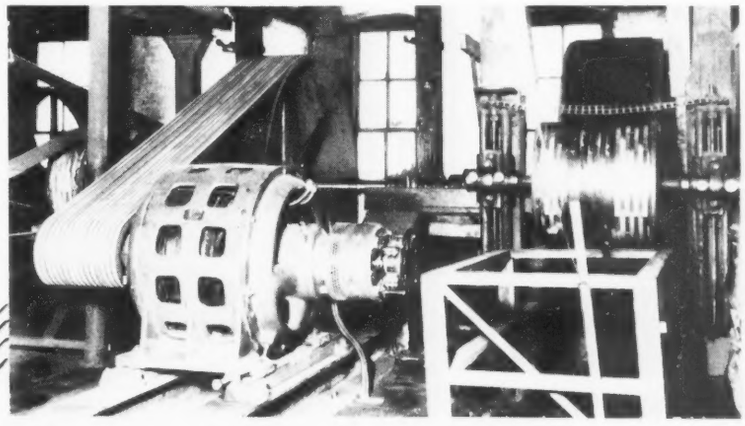
No. of Poles	R.P.M., 25-Cycle Class	R.P.M., 60-Cycle Class	No. of Poles	R.P.M., 25-Cycle Class	R.P.M., 60-Cycle Class
2	1,500	3,600	12	250	600
4	750	1,800	14	214.3	514.3
6	500	1,200	16	187.5	450
8	375	900	18	166.7	400
10	300	720	20	150	360

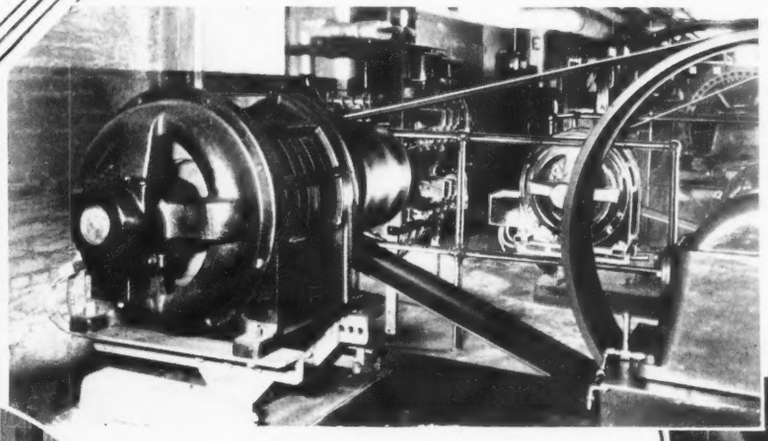
speed must likewise be slow for direct connection, meaning high initial cost and low efficiency with d.-c. motors, poor power factor and increased power costs with a.-c. motors. Table II brings out the comparisons, showing the advantages of 1,750-r.p.m. motors with speed reducers over direct-connected slow-speed motors. The comparison is based on general-purpose, squirrel-cage motors, flat and multiple V-belts, silent chains, and gearmotors. In each case, *all* equipment necessary to connect the motor to its load is included. Coupling cost is added in the case of gearmotors and direct-connected motors. Cost of a pivot base is added on flat-belt drives, cost of a sliding base on V-belt and chain drives.

These costs should not be taken as correct for all conditions; they vary over a wide range, except for costs of gearmotors. Belt, V-belt, and chain-drive costs are based on approximately minimum center distances, while in practice these distances may be almost anything, depending upon conditions.

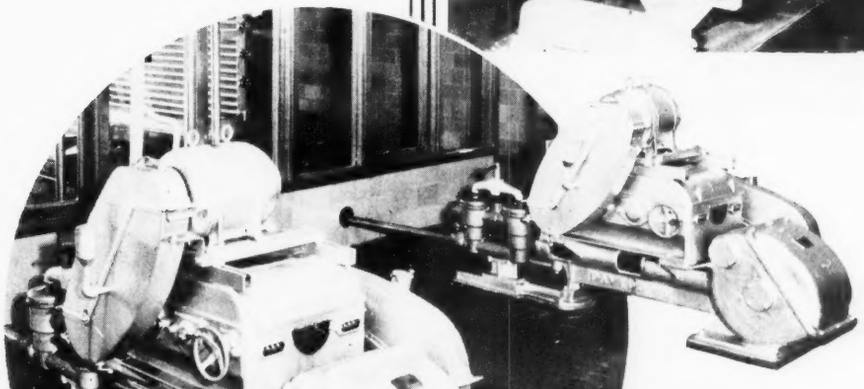
Now, as to use of the Table: Assume a 10-hp. motor is selected to drive a machine with an input-shaft speed of 430 r.p.m. A direct-connected motor for this speed will cost $438, including coupling, and will weigh 730 lb. A 1,750-r.p.m. motor will cost $121 and weigh 275 lb. With a flat belt and ready to connect to the load, this motor will cost $158, with a multiple V-belt $189, with a silent chain $201. A gearmotor will cost $281, highest of the four high-speed motor arrangements but still $157 less than the slow-speed motor and half the weight—365 lb. instead of 730.

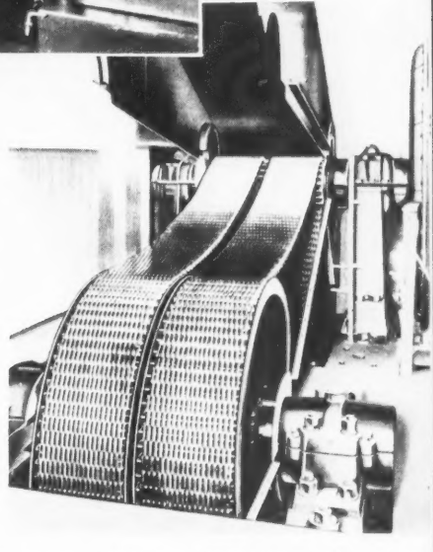
Let's go on to compare power costs for operating these motors. Assume the motors operate full load 8 hr. per day, 300 days a year, and that power costs 2 cents a kw.-hr., but with a clause in the contract which decreases the power bill 0.5% for each per cent the power factor is above 0.85, and increases it 0.5% for each per cent the power factor is below 0.85. Full-





Upper right—Multiple-V belt meets short center-distance requirements for operating a 150-kw. generator from a lineshaft, driven in turn by steam engine through the flat belt at right. Right—Mounting 125-hp. and 75-hp. high-speed motors on pivoted bases permits use of low-cost flat belts on short centers for slow-speed air-compressor drives. Below—Mechanical variable-speed transmissions drive these milk pumps at any speed over a required range of 4 to 1 with constant-speed, high-efficiency motors and silent-chain drives. Entire equipment is mounted compactly on pump





Right — Silent-chain drive from 750-hp. high-speed motor to rubber-mill lineshaft gives large power capacity in small space

MOTOR & TRANSMISSION COSTS

THIS table shows advantages of a 1,750-r.p.m. motor with belt, chain, or gear drive over direct-connected motors of slower speeds (1,160-, 570-, and 430-r.p.m.). The 3,500-r.p.m. motor has been omitted because its cost is higher, its efficiency lower than a 1,750-r.p.m. unit of comparable rating, and it is not well adapted for use with belt, chain or gear drives. Figures given in the table should not be accepted as exact values, for some may vary widely with different sets of conditions.

The first ten columns from the left apply to a line of general-purpose, squirrel-cage induction motors operating at full-load speeds of approximately 1,750, 1,160, 570 and 430 r.p.m. Prices in Column 9 are net to user. For the 1,750-r.p.m. motor, prices are for motor only; at other speeds they include a flexible coupling. Column 11 gives input-shaft speeds of the driven machines. Column 12 gives combined full-load efficiencies of 1,750-r.p.m. motors and speed reducers, in all cases considered 2% less than full-load motor efficiency. Full-load power factors in Column 13 are for 1,750-r.p.m. motors. Columns 14, 15 and 16 give list prices to users of 1,750-r.p.m. motors and a flat belt, a multiple V-belt and a chain drive to give corresponding speeds, listed under "Output-Shaft Speed." Chain cost includes an inclosing case. For the flat-belt drive, the motor is mounted on a pivot base, and for the V-belt and chain drives, slide rails are provided. Prices include everything, except controller and installation costs, for connecting the motor to its load.

Prices may vary widely depending upon existing conditions and should not be accepted as a comparison between different kinds of mechanical power-transmission equipment. Price is one factor only in the problem of selecting mechanical power-transmission equipment, and the economical answer can be obtained only by considering all elements in each installation. The last three columns on the right give net prices to user, weights and over-all lengths for a line of 1,750-r.p.m. gearmotors with output speeds corresponding to those in the output-shaft-speed column. These prices include a flexible coupling on the output shaft. Prices for a separate motor and gear reducer would be considerably higher than those for the gearmotor.

TABLE II—Comparison of 1,750-R.P.M., General-Purpose, Squirrel-Cage, Induction Motors and Speed Reducers to Obtain 1,160, 570 and 430 R.P.M., With Direct-Connected Motors for These Speeds

	Motor Only									Motor and Transmission Unit			Cost, Dollars			Geared Motor		
Horse-power	Full-Load Speed, R.P.M.	Efficiency, % Full Load	Efficiency, % Half Load	Power Factor Full Load	Power Factor Half Load	Guar. Minimum Starting Torque, %	Weight, Lb.	Cost, $	Over-all Length, Inches	Output-Shaft Speed, R.P.M.	Full-Load Eff., %	Full-Load Power Factor	Motor and Flat Belt	Motor and V-Belt	Motor and Silent Chain	Cost, $	Weight, Lb.	Over-all Length, In.
	1,750	82	81	0.82	0.68	150	90	39	14									
1	1,160	82	81	0.75	0.51	135	100	56	20	1,160	80	0.82	54	56	71	96	100	16
	570	73	66	0.56	0.38	115	147	110	23	570	80	0.82	55	60	73	96	100	16
	430	62	52	0.42	0.29	100	275	153	26	430	80	0.82	56	62	79	99	100	16
	1,750	84	82	0.85	0.77	150	135	58	17									
2	1,160	82	81	0.76	0.55	135	150	76	22	1,160	80	0.86	73	80	91	115	160	19
	570	81	76	0.63	0.44	115	275	149	26	570	80	0.86	75	83	94	117	160	19
	430	75	69	0.53	0.35	100	415	235	30	430	80	0.86	78	86	100	120	160	19
	1,750	84	83	0.86	0.62	150	135	64	20									
3	1,160	81	79	0.79	0.62	135	150	86	23	1,160	82	0.86	80	88	97	131	160	19
	570	81	78	0.65	0.46	115	305	175	27	570	82	0.86	82	95	104	134	160	19
	430	76	71	0.61	0.39	100	515	276	32	430	82	0.86	84	100	108	136	160	19
	1,750	86	85	0.86	0.72	150	147	80	20									
5	1,160	86	84	0.81	0.64	135	203	108	23	1,160	84	0.86	98	109	118	143	190	22
	570	85	80	0.64	0.45	115	415	228	30	570	84	0.86	101	114	126	148	190	22
	430	77	73	0.66	0.35	100	560	320	33	430	84	0.86	103	120	133	151	190	22
	1,750	88	87	0.88	0.77	150	203	102	23									
7½	1,160	86	85	0.87	0.73	135	275	138	26	1,160	86	0.88	128	140	149	180	250	24
	570	84	80	0.65	0.64	115	515	269	32	570	86	0.88	132	150	162	184	250	24
	430	78	75	0.69	0.52	100	730	364	37	430	86	0.88	135	155	170	187	250	24
	1,750	89	88	0.88	0.83	150	275	121	26									
10	1,160	86	85	0.87	0.75	135	305	164	27	1,160	87	0.88	148	172	179	268	365	27
	570	84	78	0.69	0.49	115	560	315	33	570	87	0.88	154	178	192	274	365	27
	430	79	78	0.67	0.48	100	730	438	39	430	87	0.88	158	189	201	281	365	27
	1,750	89	89	0.90	0.84	150	305	151	27									
15	1,160	88	88	0.88	0.79	135	415	210	29	1,160	87	0.90	190	220	217	319	395	29
	570	86	85	0.73	0.54	120	730	361	36	570	87	0.90	198	226	222	333	395	29
	430	80	79	0.68	0.51	100	1,110	511	41	430	87	0.90	206	249	229	340	395	29
	1,750	90	89	0.90	0.88	150	380	179	29									
20	1,160	90	90	0.89	0.80	135	515	245	32	1,160	88	0.90	215	244	241	350	530	31
	570	87	86	0.79	0.69	120	730	427	39	570	88	0.90	229	258	262	374	530	31
	430	82	81	0.72	0.54	100	1,450	597	44	430	88	0.90	241	266	272	385	530	31
	1,750	90	90	0.93	0.89	150	415	207	25									
25	1,160	90	91	0.87	0.80	135	560	282	33	1,160	88	0.93	264	275	285	389	560	32
	570	88	87	0.78	0.62	115	1,110	490	41	570	88	0.93	276	303	300	403	560	32
	430	83	82	0.71	0.52	100	1,910	665	49	430	88	0.93	286	312	310	415	560	32
	1,750	91	89	0.93	0.90	150	560	269	33									
30	1,160	91	91	0.86	0.80	135	730	319	36	1,160	89	0.93	323	346	...	481	735	35
	570	89	89	0.80	0.64	115	1,220	581	45	570	89	0.93	342	373		501	735	35
	430	84	81	0.67	0.49	100	1,910	739	51	430	89	0.93	356	448	...	518	735	35
	1,750	91	87	0.93	0.89	150	730	319	36									
40	1,160	91	91	0.89	0.79	135	810	381	38	1,160	89	0.93	393	411	...	536	1,050	39
	570	86	86	0.82	0.67	115	1,910	650	49	570	89	0.93	316	445	...	554	1,050	39
	430	88	87	0.71	0.51	100	2,200	867	53	430	89	0.93	337	467	...	582	1,050	39
	1,750	91	88	0.94	0.90	150	810	382	36									
50	1,160	89	87	0.90	0.81	135	1,110	440	41	1,160	89	0.94	464	490	...	618	1,090	41
	570	86	86	0.81	0.64	115	1,910	741	49	570	89	0.94	494	548	...	644	1,090	41
	430	89	87	0.76	0.56	100	2,200	984	53	430	89	0.94	519	580	...	673	1,090	41
	1,750	91	89	0.94	0.90	150	1,220	521	39									
75	1,160	91	89	0.93	0.84	135	1,540	617	48	1,160	89	0.94	669	695	...	863	1,450	46
	570	91	91	0.80	0.63	115	2,200	954	53	570	89	0.94	700	729	...	886	1,450	46
	430	89	88	0.78	0.60	100	3,085	1,243	58	430	89	0.94	730	767	...	933	1,450	46
	1,750	91	89	0.94	0.90	150	1,540	666	50									
100	1,160	92	90	0.91	0.81	135	1,910	804	52	1,160	89	0.94	882	947	...	...	...	...
	570	90	89	0.84	0.69	115	2,900	1,168	55	570	89	0.94	917	984	...	...	...	...
	430	89	86	0.78	0.65	100	3,700	1,479	59	430	89	0.94	949	1,015	...	...	...	...

load efficiency and power factor of the 1,750-r.p.m. motor with a speed reducer are 87 and 88%, compared to 79 and 67 respectively for the direct-connected 430-r.p.m. motor. Because of this, power for the 1,750-r.p.m. motor will cost only $405 per year, compared to $497 for the 430-r.p.m. unit, a difference of $92.

Even at 1,160 r.p.m., the 1,750-r.p.m. motor and a flat belt or a multiple V-belt costs practically the same as a 1,160-r.p.m. direct-connected motor. The better efficiency and power factor of the 1,750-r.p.m. motor may give it an advantage, even with a high-cost speed reducer, over the 1,160-r.p.m. motor direct-connected to its load.

Over-all length of the 1,750-r.p.m. motor and speed reducer likewise is less than that of the 430-r.p.m. machine. Over-all length of a 1,750-r.p.m. motor is 26 in., but with a belt or chain drive the motor shaft will overlap the driven shaft about 3 in. Consequently, the motor requires only 23 in. beyond the driven-shaft end, compared to the 39-in. over-all length of a 430-r.p.m. direct-connected motor. Even the gearmotor is only 27 in. long, 12 in. less than the slow-speed unit.

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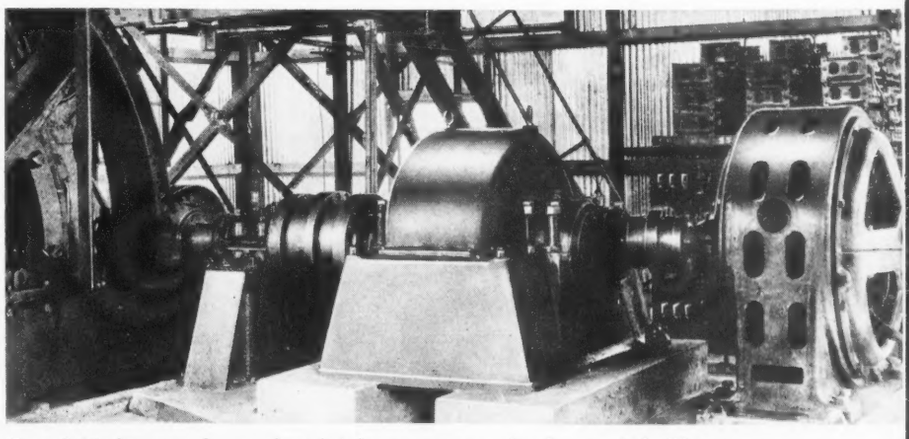
COUPLINGS AND CLUTCHES . . . . .



Large-hoist drum speeds are slow, but here a gear speed reducer and flexible couplings permit drive from a high-speed, low-cost, wound-rotor, induction motor

COMMONEST "harness" between power unit and a direct- or gear-connected load is the flexible coupling. If the gear is not integral with power unit or driven unit, a flexible coupling is used each side of it. Other speed-reducing or increasing equipments often require couplings also.

Couplings are usually rated as capable of "transmitting so-many horsepower at 100 r.p.m.," based on most favorable conditions of easy starting and constant load. Rating usually increases directly with speed; thus a coupling rated 10 hp. at 100 r.p.m. is good for 50 hp. at 500 r.p.m. Service factors like those in Table III correct for variations in load and drive. On any ordinary drive, they will give a satisfactory result, but if you have a special drive problem, consult the coupling manufacturer.

The capacity of a coupling in horsepower per 100 r.p.m. for a given application can be determined by this formula:

$$Coupling\ Capacity = (Hp. \times F \times 100) \div S$$

where $Hp.$ is the horsepower rating of the power unit, F the service factor and S the speed in r.p.m. at which the coupling is to operate.

Assume couplings for a 20-hp., 1,750-r.p.m. motor to drive a belt conveyor through a 10-to-1 gear reducer. A coupling will be required on each side of the reducer. Service factor from Table III is 2. Then the motor-coupling rating at 100 r.p.m. is $(20 \times 2 \times 100) \div 1{,}750 = 2.3$ hp., and between gear and conveyor $(20 \times 2 \times 100) \div 175 = 23$ hp.

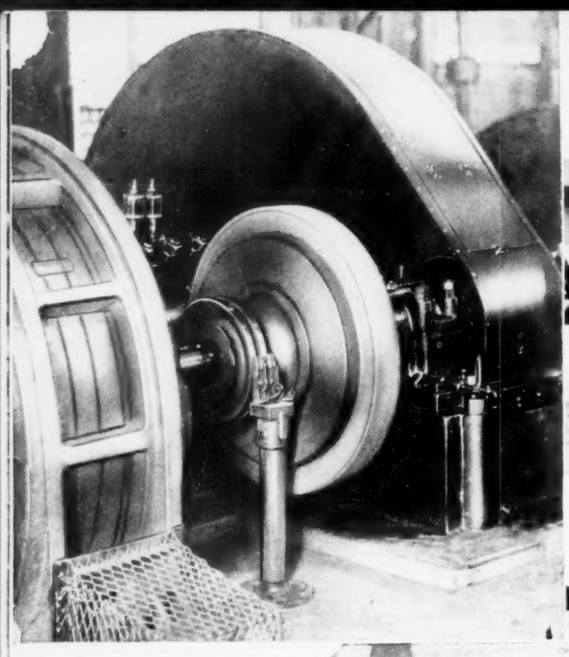
It is often desirable to bring the driving unit up to speed before connecting the load, to connect and disconnect the load at will or to provide a safety element. Here clutches and clutch-couplings are used. For example, a long lineshaft driving a number of machines may be divided into sections by clutches so that the groups can be started and stopped at will, thus reducing power costs and wear on equipment. In some group drives, the power source is belted to a stub shaft beween two lineshafts and connected to them by clutches.

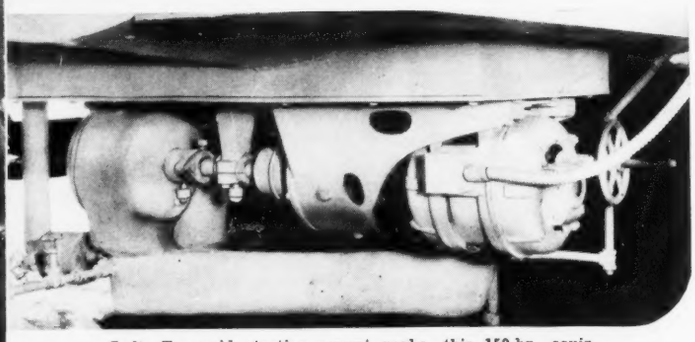
High-inertia loads like centrifugals, hammer mills, loads with heavy flywheels, etc., require oversize engines or high-starting-torque motors with expensive control if they are started directly by the driving unit. A clutch or clutch-coupling permits use of a power drive only large enough to drive the load, for example a simple squirrel-cage motor started by connecting across the line. Such an arrangement avoids high starting shocks and load peaks, and often halves motor capacity required.

Clutches may be divided into three classes: jaw, friction and magnetic. Jaw clutches are mainly applicable to slow-speed shafts where they can be engaged and disengaged at rest. Friction and magnetic types

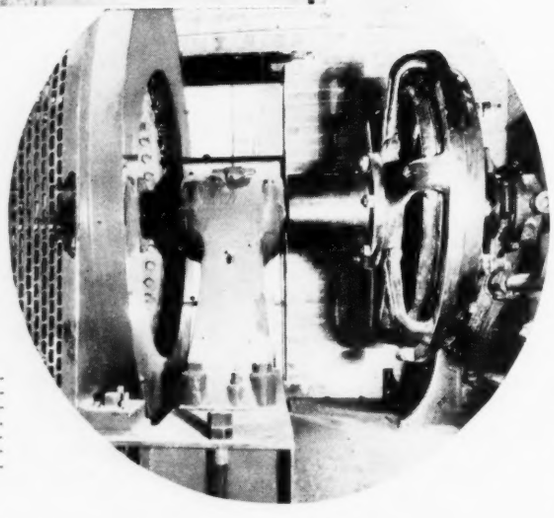
Table III—Service Factors for Flexible Couplings

Drive	Driven Unit	Service Factor
Turbine	Centrifugal pumps and fans	1.25
Turbine	Generator	1.5
Motor	Centrifugal pumps and fans, blowers	1.5
Motor	Belt conveyor, bucket elevators, smooth load grinders, generators, factory lineshafts, light wood-working machinery	2
Motor	Triplex and duplex pumps, centrifugal dredge pumps, vacuum pumps, stokers	3
Motor	Screw conveyors, hoist, cranes, crushers, tube mills, pulverizers, hogs (steel, rubber and brass rolling mills), pulverized-fuel pumps, wood planers and surfacers	4
Motor	Compressor and well-drilling rigs	5
Engine	Centrifugal pumps and generators	3
Engine	Plunger pumps and centrifugal dredge pumps, stokers	4
Engine	Fans, blowers	5
Engine	Compressors	7





Left—To avoid starting-current peaks, this 150-hp. squirrel-cage motor is started unloaded, then connected to a geared accumulator pump by a magnetic clutch. Above—A simple 20-hp. normal-torque gearmotor can be used for a high-starting-torque load by using an automatic clutch-coupling, as on this soap-pump drive



High power factor, efficiency and low starting-current are here combined by using a 400-hp. synchronous motor connected to a grain-elevator lineshaft by a friction clutch

can be opened and closed under full load at full speed. Magnetic clutches are highest in first cost and require d.-c. power, but are easiest to control, requiring only a pushbutton, float switch, pressure switch, etc., near or remote.

Clutches are usually designed to start and bring their rated load to full speed in 4 to 8 sec. If this time must be less, capacity must be proportionally greater. Suddenly applied loads must be doubled when determining clutch capacity. With internal-combustion engines, increase clutch capacity 100% for single-cylinder engines, 50% for 2-cyl. engines, 25% for four or more cylinders. If a clutch is to be engaged one or more times per hour, add 2% to required horsepower for each engagement. When you aren't sure what is good practice in selecting clutches, consult manufacturers.

Essentially, a clutch coupling is some form of automatic clutch built into a somewhat enlarged coupling. Its friction element is keyed to the motor or prime-mover shaft, its drum to the driven shaft. The driving unit is accelerated without load until centrifugal force causes the friction shoes to engage the drum at a predetermined speed and accelerate the load as the driver comes up to full speed. Clutch couplings may be used either for direct connection or in combination with a pulley or sheave. Some types will take a little misalignment. Use a flexible coupling with the clutch coupling where greater flexibility is required.

Free-wheeling clutches have come into quite general use on dual drives from two power sources, on 2-speed drives and similar applications. As long as the power unit is driving, this clutch stays engaged, but if the driver slows up or the load speeds up, the clutch releases until they are again operating at the same speed. An example is a load driven by a multi-speed motor. When changing from a higher to a lower speed, a free-wheeling clutch will prevent shocks due to braking action of the motor.

▼ ▼ ▼

FLAT BELTS . . . . .

FLAT belts, simplest and among the oldest of power-transmission media, still occupy an outstanding position—in fact their popularity is increasing. Leather and rubber constructions probably represent over 95% of the flat belts in use, although there are many other possible materials: balata, stitched cotton duck, camels' hair, and steel, for example.

Flat belts are adapted to high- or low-speed applications—they are readily used for speeds up to 5,000 f.p.m. and have been operated at twice that speed. Up to about 5,000 f.p.m., power that can be transmitted by a given belt increases with speed; beyond this, centrifugal force and other factors take their toll. That is why a belt running at 7,500 f.p.m. has about the same rating as one running at 3,000.

Belts are readily adapted to changed conditions. Length can be increased or decreased easily to meet changed drive requirements, and they can be operated on either long or short centers. Long-center drives with the slack side on top were once the more desirable

arrangement, but development of pivoted bases for motors has made short-center drives as satisfactory as long-center ones.

When a motor is mounted on a pivoted base, part of its weight is balanced against the tension in the two strands of the belt. Bases have been developed for operating the motor in almost any position. The motor can be shifted nearer to or farther from the pivot on the base thus positioning the motor to operate with minimum belt tension to drive the load and with least wear and tear.

On applications where pulley ratios are small, these drives may operate on such short centers the pulleys almost touch. For example, 7.5-hp., 1,750-r.p.m. motors drive spinning frames with only 10 in. between pulley centers. These drives are also suited for large pulley ratios and center distances comparable to or shorter than idler applications. An example is a 15-hp., 1,160-r.p.m. motor driving a paper calender through a belt on 32-in. centers with a speed reduction of 8 to 1.

Leather belts are available in light, medium and heavy, single-, double- and triple-ply, for application according to horsepower to be transmitted and size of pulleys, Table IV. Rubber belts are made in thicknesses of from 2- to 15-ply and widths of 1 to 72 in. Above 10-ply, these belts may be considered special for high-powered drives for operation on large pulleys. It is desirable on any drive to use as thin a belt as possible consistent with a practical width. Table V gives minimum pulley diameters and horsepower per inch of rubber belt.

Values given in the tables are fairly representative of leather and rubber belts. Some are available with higher or lower ratings, but the values in the tables will give satisfactory results.

Most power applications require a belt of higher rating than the drive unit. Allowance must be made for character of load, method of starting and other conditions by the use of service factors such as those in Table VI. Another factor is the arc of contact of the belt on the smaller pulley. Belts are usually rated on the basis of 180-deg. arc of contact.

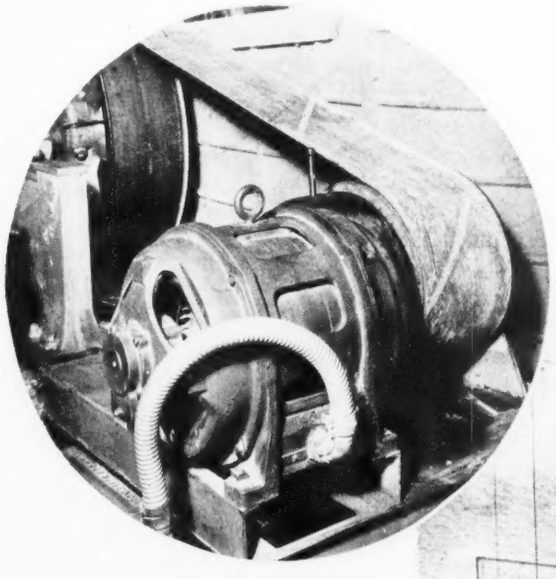
Assume a belt conveyor driven by a 25-hp., 1,150-r.p.m. slip-ring motor on a pivoted base, with the motor pulley 12 in. in diameter and belted to a 42-in. pulley, center-to-center distance being 6 ft. Horsepower of the belt can be found by the formula: *Belt hp. = motor hp. × service factor × arc of contact factor.* In Table VI, a service factor of 2 is given. Arc of contact on the small pulley may be determined by the formula:

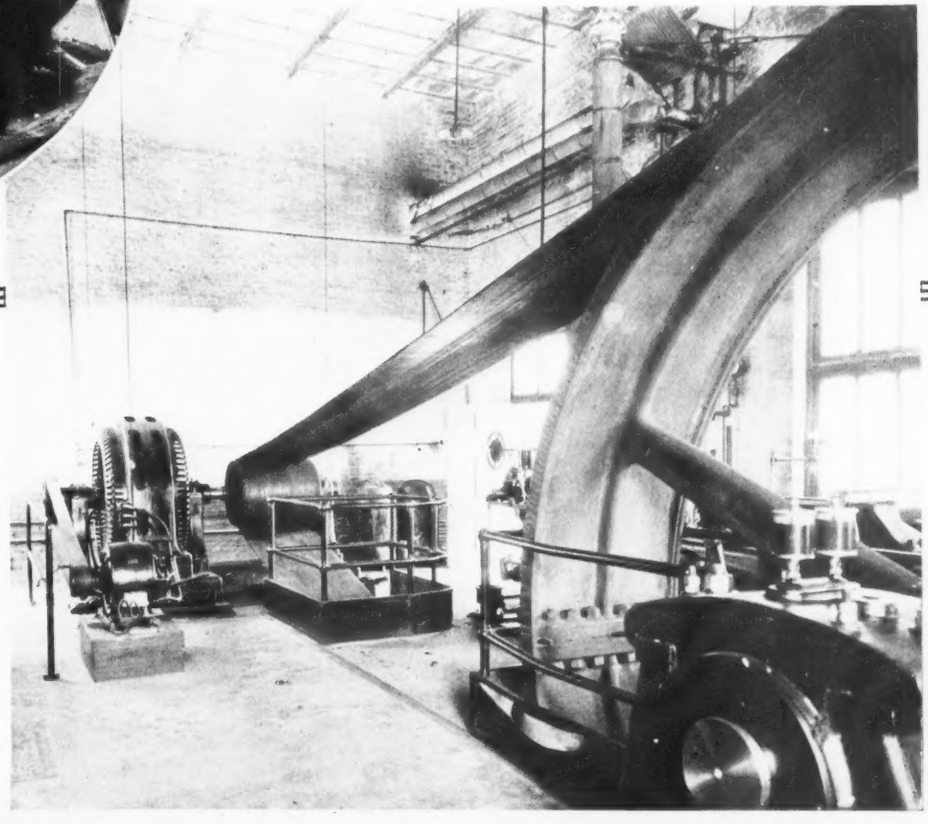
$$Arc\ of\ Contact = 180 - \frac{60\ (D - d)}{C}$$

Where D is the diameter of the larger pulley and d of the smaller and C equals the center-to-center distance, all dimensions being in inches. Then,

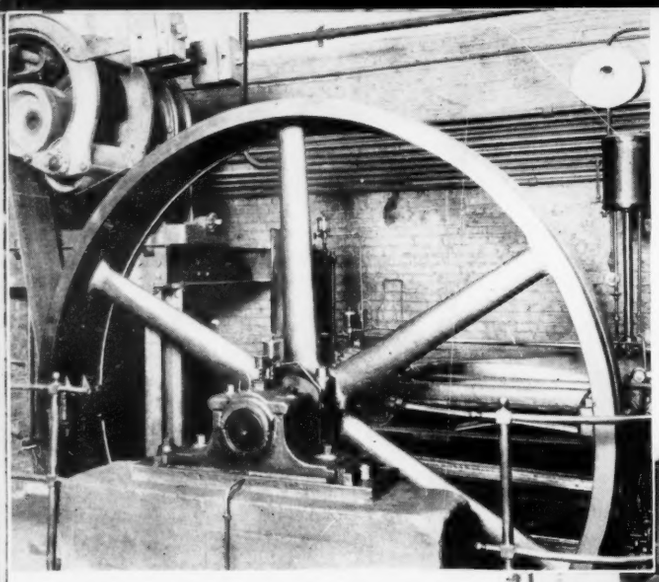
$$Arc\ of\ Contact = 180 - \frac{60 \times (42 - 10)}{72} = 153\ \text{deg.}$$

In Table VII the correction factor for 150 deg. is 1.13. Consequently, *Belt hp.* $= 25 \times 2 \times 1.13 =$ 56.5. To determine the size of the belt its speed must be known, which for a 12-in. pulley at 1,150 r.p.m. is found to be 3,600 ft. per min. (See Data Sheet, page

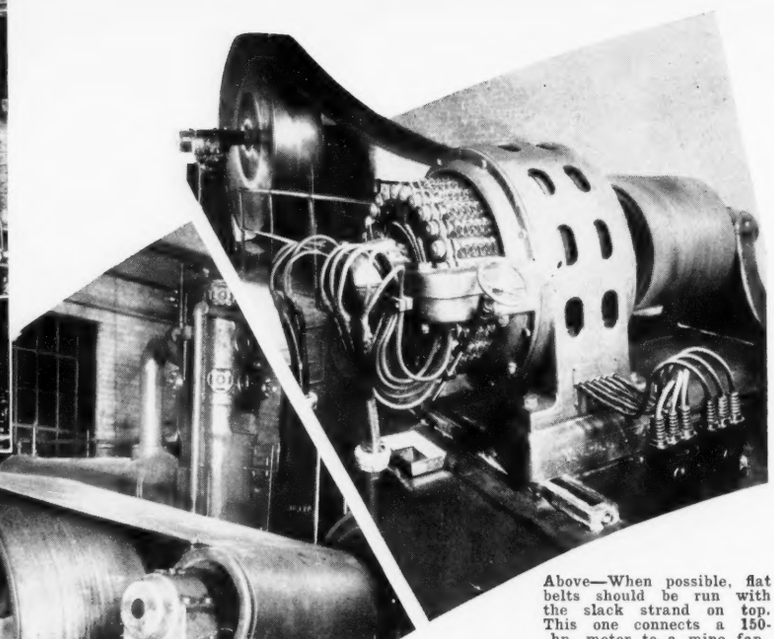




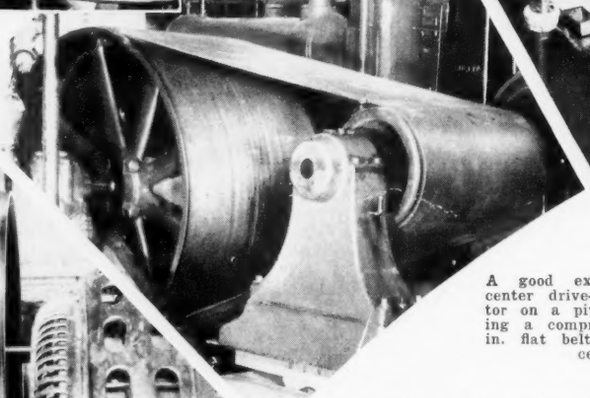
Above—To obtain the slow speed required for a paper-mill beater and use a high-speed low-cost motor, a 1,750-r.p.m. gearmotor on pivoted base is belt-connected for 12.5:1 reduction. Right—Where space permits, large high-speed generators can be driven efficiently from the flywheel of a slow-speed engine, as is this 400-kw. alternator. Exciter also belted to alternator



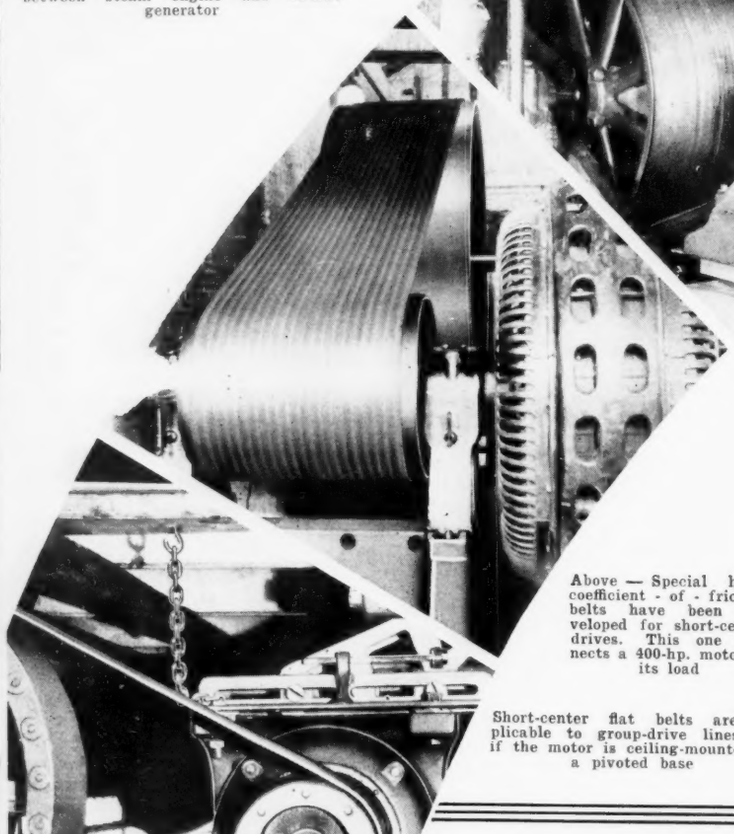
Flat belts may be used on short centers for very large speed ratios by using tension idlers, as on this drive between steam engine and 90-kw. generator



Above—When possible, flat belts should be run with the slack strand on top. This one connects a 150-hp. motor to a mine fan



A good example of short-center drive—a 400-hp. motor on a pivoted base driving a compressor by a 38-in. flat belt on 7-ft. shaft centers



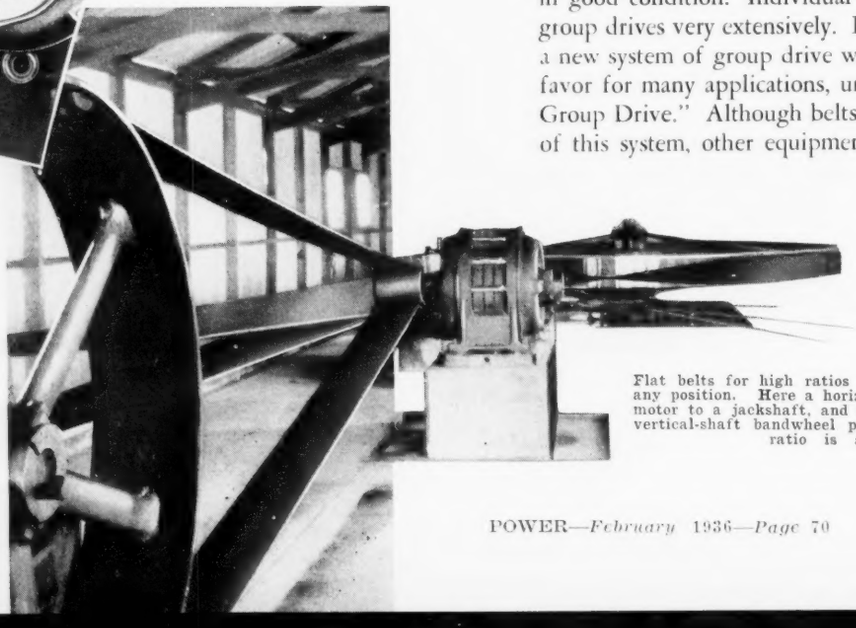
Above — Special high-coefficient - of - friction belts have been developed for short-center drives. This one connects a 400-hp. motor to its load

Short-center flat belts are applicable to group-drive lineshafts if the motor is ceiling-mounted on a pivoted base

96). If a leather belt is selected, use Table IV. A heavy single-ply belt will transmit 5.9 hp. per in. of width at 3,500 f.p.m. and 6 hp. at 3,600 f.p.m. Then a belt having a width of $56.5 \div 6 = 9$ in., will do the job. The pulley should be about an inch wider than the belt, so that one with a 10-in. face can be used.

If a rubber belt is selected, one of 5-ply construction can be used, which at 3,600 f.p.m. is good for about 6.5 hp. per in. of width. Belt width should be $56.5 \div 6.5 = 9$ in., and the pulley can be 10 in. wide. For good pulley proportions, select a face width equal to or less than the diameter. If possible when selecting the small pulley, choose one that will give the most economical belt speed, 4,000 ft. per min.

Before general adoption of electric motors, most drives were group arrangements. In some cases, equipment on several floors, or in several buildings, was driven from one steam engine or waterwheel through belts, shafting and gears. This method was inefficient and power losses were high, even when equipment was in good condition. Individual drives began to replace group drives very extensively. In recent years, however, a new system of group drive was developed and found favor for many applications, under the name "Modern Group Drive." Although belts form an important part of this system, other equipment, such as chains, gears



Flat belts for high ratios may be operated in almost any position. Here a horizontal belt connects a 60-hp. motor to a jackshaft, and a quarter-turn belt drives a vertical-shaft bandwheel pumping 22 oil wells. Speed ratio is about 100:1

Table IV—Minimum Pulley Diameters and Permissible Horsepower of Leather Belt Per Inch Width (180-deg. Arc Contact)

	Min. Pulley Diam., Inches			Maximum Permissible Horsepower Per Inch of Belt Width								
	Speed, Ft. per Min.											
	Under	2,000	Over	Belt Speed, Ft. per Min.								
Plys[1]	2,000	4,000	4,000	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
1-L	2	3	4	1.4	2.0	2.6	3.3	3.8	4.3	4.6	5.0	5.3
1-M	3	5	6	1.6	2.4	3.2	3.9	4.6	5.1	5.6	6.0	6.3
1-H	4	6	7	1.9	2.8	3.7	4.6	5.4	5.9	6.5	7.0	7.4
2-L	7	9	12	2.1	3.0	4.0	5.0	5.8	6.5	7.0	7.5	8.0
2-M	9	12	14	2.5	3.7	4.8	5.9	7.1	7.8	8.5	9.1	9.7
2-H	14	18	20	2.8	4.0	5.3	6.5	7.7	8.5	9.3	10.0	10.5
3-L	22	24	32	2.9	4.2	5.5	6.8	8.0	8.8	9.6	10.3	11.0
3-M	24	32	36	3.3	4.8	6.3	7.8	9.2	10.2	11.1	11.9	12.6
3-H	28	36	42	3.7	5.5	7.2	8.8	10.5	11.6	12.6	13.5	14.3

[1] L = light, M = medium and H = heavy.

Table V—Minimum Pulley Diameters and Permissible Horsepower Rubber Belt Per Inch Width (180-deg. Arc of Contact)

	Min. Pulley Diam., Inches			Maximum Permissible Horsepower Per Inch of Belt Width								
	Speed, Ft. per Min.											
	Under	2,000-	Over	Belt Speed, Ft. per Min.								
Plys	2,000	4,000	4,000	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
3	4	5	6	1.2	1.7	2.3	2.8	3.3	3.8	4.1	4.4	4.7
4	6	8	10	1.6	2.3	3.0	3.8	4.4	5.1	5.5	5.9	6.3
5	8	10	12	2.0	2.9	3.8	4.7	5.4	6.4	6.9	7.5	7.9
6	10	12	16	2.4	3.5	4.5	5.7	6.5	7.6	8.3	9.0	9.4
7	14	16	20	2.8	4.1	5.3	6.6	7.6	8.9	9.7	10.4	11.0
8	18	20	24	3.2	4.7	6.0	7.6	8.7	10.2	11.0	11.9	12.6
9	22	24	30	3.6	5.3	6.8	8.5	9.8	11.4	12.5	13.4	14.1
10	30	36	42	4.0	5.8	7.5	9.5	10.8	12.7	13.8	14.9	15.7
12	36	42	48	4.9	7.0	9.2	11.7	13.4	15.6	16.9	18.2	19.2

Table VI—Service Factors by Which Normal Rating of Motors Must be Increased When Selecting Belts to Connect Them to Their Loads

Kind of Load	Typical Machinery	Service Factor
Starting load light—operating load normal	Small fans, blowers and centrifugal pumps	1
Light, pulsating—starting peaks 125% of normal	Small reciprocating pumps and compressors; line shafts driving light loads	1.2
Moderate shocks or pulsations—starting peak loads 150% of normal	Reversing drives, large compressors and pumps, large fans and blowers, pulverizers	1.4
Severe shocks or pulsations — starting peak loads 200% of normal	Mining and smelting machinery, mud pumps, etc.	1.75
Starting on peak loads up to 250% of normal	Textile machinery such as spinning frames and twisters, coal and similar conveyors	2
Severe shocks and stalling tendencies	Crushers, drag lines and other machinery driven by slip-ring motors	2
Motors started by connecting directly across the line; never less than		2

Table VII—Correction Factors for Arc of Contact

Arc of Contact, Deg.	Correction Factor	Arc of Contact, Deg.	Correction Factor	Arc of Contact, Deg.	Correction Factor
180	1	160	1.08	140	1.18
170	1.04	150	1.13	130	1.23

and V-belts and combinations of them, are also used.

This system differs from the old in many respects. It is intended for comparatively small groups of small- and medium-powered machines. Comparatively short, light, high-speed shafting operates in anti-friction bearings, supported in improved hangers on a system of steel channels attached to the building. This steel work not only provides a good support for the shafting but it also permits bearings to be located at load points along the shafting, insuring minimum shaft distortion. The shafting can also be kept in line conveniently and the anti-friction bearings used insure high operating efficiency.

Where it is applicable, modern group drive costs less than individual drives; installed horsepower can be less, and the larger motors will have a higher power factor than small motors. This, combined with higher efficiency, reduces power costs.

The system has the disadvantage that if a motor fails, a group of machines is shut down. With modern motors properly installed and maintained, this objection can be discounted considerably, because of high reliability of electrical equipment. Be these arguments what they may, modern group drive has given power-application engineers a new tool worthy of careful consideration.

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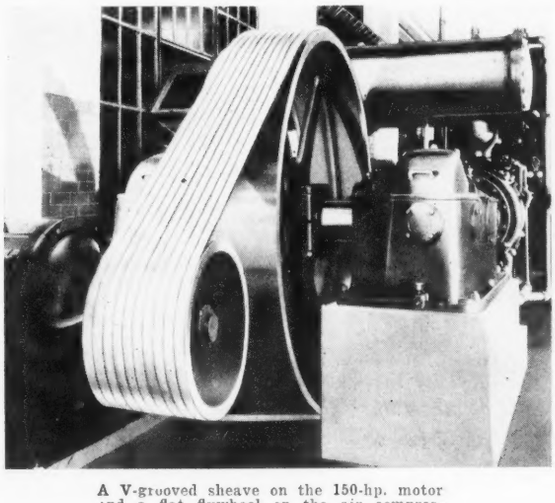
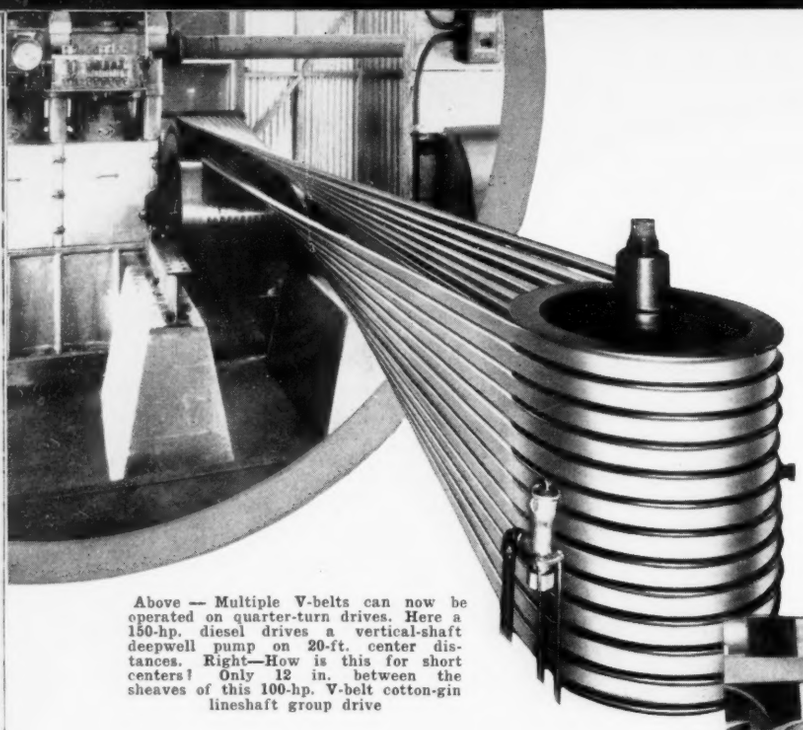
MULTIPLE V-BELTS . . . . .

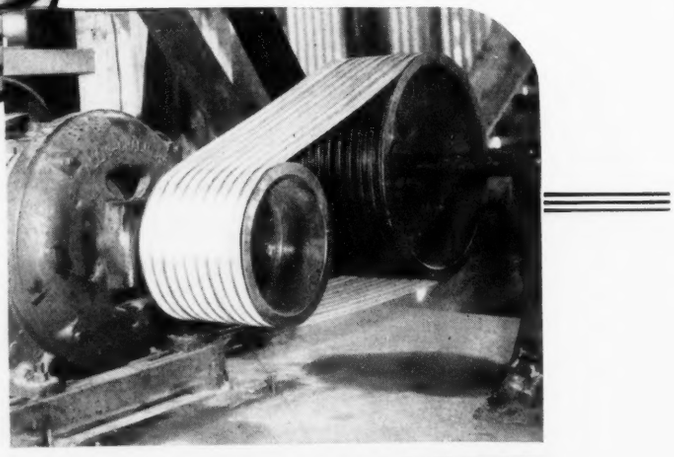


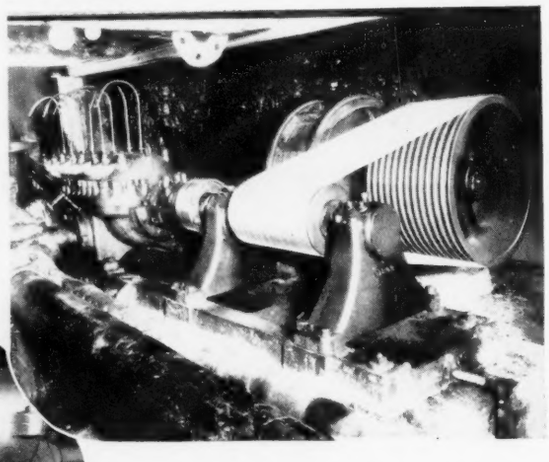
A V-grooved sheave on the 150-hp. motor and a flat flywheel on the air compressor, yet V-belts can be used for the drive

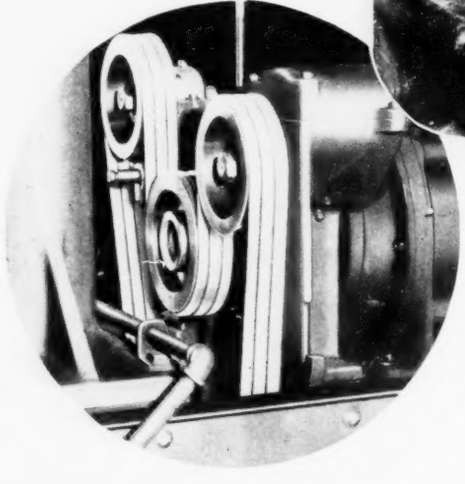
MULTIPLE V-belt drives are comparatively new, but they have won an important place where short-center drives are required. Developed originally to operate only on aligned V-grooved pulleys with shafts parallel, V-belts are now available to operate on quarter-turn drives with and without idlers, on drives using two idlers to reverse rotation of the driven pulley, on drives using a V-grooved driver and a flat-rimmed driven pulley, on drives with adjustable pitch-diameter sheaves permitting up to 50% speed adjustment, or on drives for several shafts driven in the same or opposite directions by the same belt. Many of the latter applications require a belt with a double-V cross-section so that they may drive from both inside and outside. A drive with one grooved pulley and one flat one is illus-



Above — Multiple V-belts can now be operated on quarter-turn drives. Here a 150-hp. diesel drives a vertical-shaft deepwell pump on 20-ft. center distances. Right—How is this for short centers? Only 12 in. between the sheaves of this 100-hp. V-belt cotton-gin lineshaft group drive







Above right—Most multiple V-belt drives are used to reduce speed, but this one increases it from 720 to 2,300 r.p.m., operates at 6,000 f.p.m., and connects a 150-hp. motor to a high-head mine pump. Circle — Double V-belts are now available that drive from both inside and outside, as on this automatic spooler. Lower sheave on motor; two driven sheaves above

trated at the bottom of page 71, showing a V-grooved sheave belted to an air-compressor flywheel.

Originally, V-belt sheaves were cast-iron, but now pressed-steel types are available. They are cheaper and lighter in weight than cast-iron sheaves of equivalent size, but are available only to about 15 hp. V-belts are made in five sizes, and drives comprise one or more belts of the cross-section that best suits the particular installation. Conditions governing selection are: power to be transmitted, characteristics of load and power drive and how started, center-to-center distance between sheaves, ratio of diameters of driving and driven sheaves.

Belts are rated on 180 deg. arc of contact and continuous steady load. To adjust this rating for load characteristics, service factors like those in Table VI are used. Table VI does not list factors for all machines, but for those not listed, the factor for a comparable machine may be taken.

A flywheel on the driven end will generally relieve the belts of shock loads. On the other hand, if a large part of the flywheel effect is in the driver, shock loads on the belts may be greatly increased. Unless proper allowance is made for this in selecting the belt, operation may be unsatisfactory.

Loss of arc of contact on the smaller sheave of a drive must be compensated for in selection. Actual arc of contact can be found by using the flat-belt formula (page 69) then the same factors (Table VII) may be applied.

Given kind of load, motor rating and arc of contact on the smaller sheave, the required horsepower for a V-belt can be calculated from the formula: *Required belt hp. = Motor hp. × Service factor × Arc of contact factor.* It is better to use a few too many belts than too few. Added initial cost for an extra belt or two is surprisingly small, and this additional expense will be repaid by increased life, reliability and efficiency.

When you order V-belt drives, tell the manufacturer *all* these things: maximum and minimum center distances, pitch diameters of driving and driven sheaves,

full-load speeds of driving and driven shafts, shaft-extension diameters, key-seat sizes on both shafts, type of sheave (clamp, solid-hub, or split), kind and make of driven machine, type of driver (lineshaft, motor, engine, etc.). Much of the preliminary data you can get by careful checking of manufacturers' engineering data books.

Center distances can be very short or fairly long—up to 12 ft. or more, depending on belt cross-section. Short center distances are preferable. Speed can be high or low, with ratios of 1:1 to 7:1, although ratio may go up to 10:1 on the manufacturer's recommendation. V-belts may be run in either direction, in any position, and for reversing service. Standard belts are available for speeds to 5,000 f.p.m., although the maker will sometimes permit speeds to 7,500 f.p.m. on his recommendation.

V-belts are suited to driving a wide variety of equipment, but standard types should not be used in continuous contact with mineral oil, or where center distances cannot be adjusted, or in temperatures above 140 deg. F. A recent special design will stand oil. Multiple V-belts to be used where there is excessive moisture should be selected with additional capacity to compensate for the reduction in the coefficient of friction.

When V-belts are first used, they will slacken as they seat in the grooves. This must be taken up by adjusting center distance, which will also usually take out any initial small differences in belt length. Unless the drive is too small or conditions are very severe, this adjustment should be the last required for several months, because the belts stretch only slightly after the initial stretch is compensated for.

▼ ▼ ▼

CHAIN DRIVES . . . . .

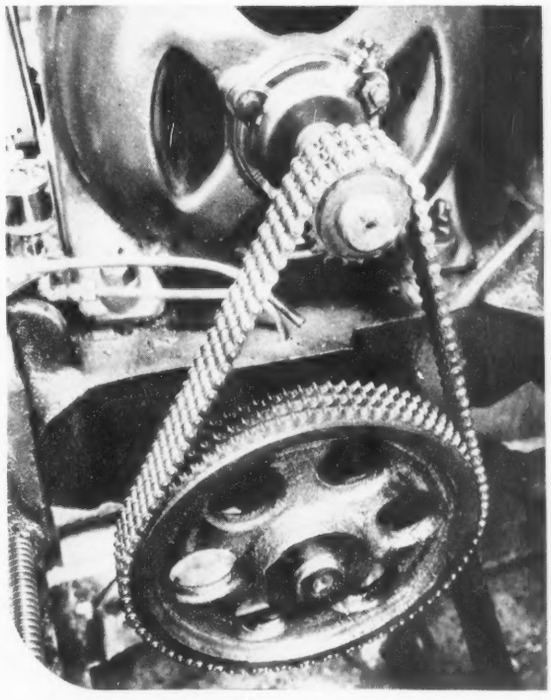
CHAIN-DRIVE types include open-end, detachable malleable-iron links on cast sprockets; closed-end pintle with malleable-iron links connected by steel pins or rivets and run on cast sprockets; bushed steel-roller chain with hardened-steel bearing surfaces and rollers; finished steel-roller single- and multiple-strand chain; silent chain. The two latter types run on cut-tooth sprockets. The first three are limited to slow-speed drives; the rest are more applicable to medium-speed drives.

Chain drives and flat and V-belts can be used interchangeably in some applications, particularly in medium-speed, small and medium-power drives. Chain drives are particularly suited for slow speeds, at high temperatures, or in dirty, oily, moist or acid atmosphere, or to transmit large power in small spaces at medium and slow speeds.

In some respects, chain drives are like gears. They transmit power at constant speed ratio and high efficiency operate in either direction and in almost any position (providing sprockets are in alignment), on long or short centers, have little tension on the slack side and consequent low bearing friction for a given transmitted load, operate quietly and with efficiencies of 98% or better when properly installed.

Detachable malleable-link chain, suited to speeds not exceeding 400 f.p.m. and sprocket ratios up to about 6.1, comprises individual iron links which can be assembled or taken apart without tools. Links are open, hence are abraded by dirt. The cast-tooth sprockets used have from 6 to 50 or more teeth, although the smaller sprocket ordinarily should not be selected with less than 10.

Closed-end pintle chain, with malleable-iron links connected by steel pins or rivets is suitable for speeds to 400 f.p.m. also, but is sturdier in construction than detachable-link designs. Joints are better protected, and the range of strengths is higher.



Chains should preferably be operated in a vertical plane, but this triple-strand roller chain runs in an inclined plane and connects a 7½-hp. 1,750-r.p.m. motor to its load

Links in bushed steel-roller chains are connected by hardened-steel bushings and pins. Strength and wearing qualities are higher than in the two preceding types, and speeds may be as high as 600 f.p.m.

Finished steel-roller chains or cut-tooth steel sprockets are intended for general-purpose capacities up to 500 hp. or more, and small sizes can operate at speeds up to 4,000 f.p.m. Bearing surfaces are case-hardened and ground, and parts are usually alloy steels.

Multiple-strand chains transmit power in excess of single-strand capacities. Double, triple, and quadruple-strand chain is carried in stock by makers, and smaller-pitch chains may be had with up to 8 strands. Power-transmitting capacity goes up practically in proportion to number of strands. Thus a greater number of strands of smaller-pitch chain can be used to transmit a given amount of power at speeds several times those recommended for single-strand chain of the required capacity.

Speed ratios can be as high as 10.1 in a single reduction, but 7.1 is a more practical top. Where large ratios are required, two or more drives in series are preferable to one of the same total ratio. On slow-speed drives, the faster-running sprocket may have a few as 7 teeth (in extreme cases teeth have been cut on an enlarged section of the driving shaft), but 11 is a safer minimum and 15 is recommended for general applications.

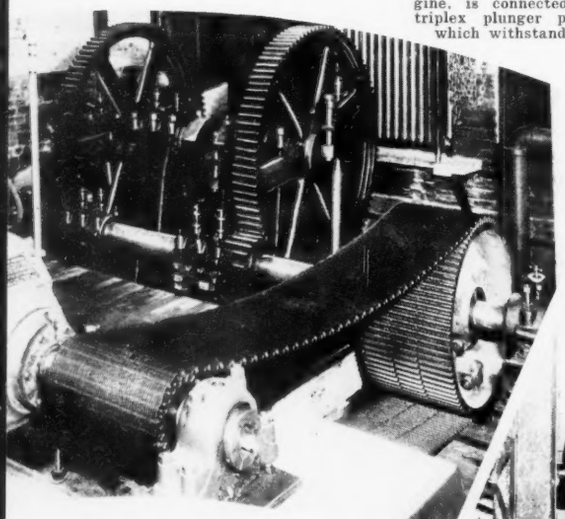
Silent chains, entirely different in design from those previously described, comprise an assembly of specially designed flat links operating on mating cut-tooth sprockets. Links are assembled on special pins which offer only slight resistance to flexing around sprockets. At first and last contact, the links mesh freely with the sprocket, but as the chain is flexed in passing around, teeth are forced outward into tight contact. This gives quiet operation.

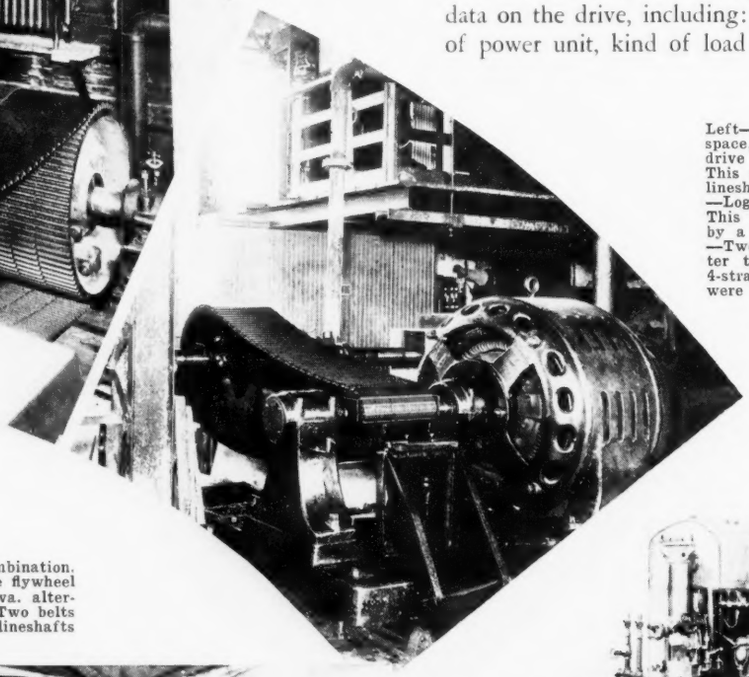
Silent-chain drives have been built in sizes from a fraction of a horsepower to 5,000. Chain speeds to 5,000 f.p.m. have been used, but 1,200 to 1,500 f.p.m. is normally most desirable. For speeds above 1,500 f.p.m., chain drives (either silent- or roller-chain types) should be enclosed to insure proper lubrication.

Factors such as characteristics of power unit and load and operating conditions modify the normal tension allowable. Reduce catalog ratings of chain 25% if they are to be subjected to severe shock loads, such as those from internal-combustion engines, air compressors, oil-well machinery, crushers, etc.

If you design drives, manufacturers' data books are invaluable. When in doubt, give the maker complete data on the drive, including: type, speed and capacity of power unit, kind of load to be driven (steady or

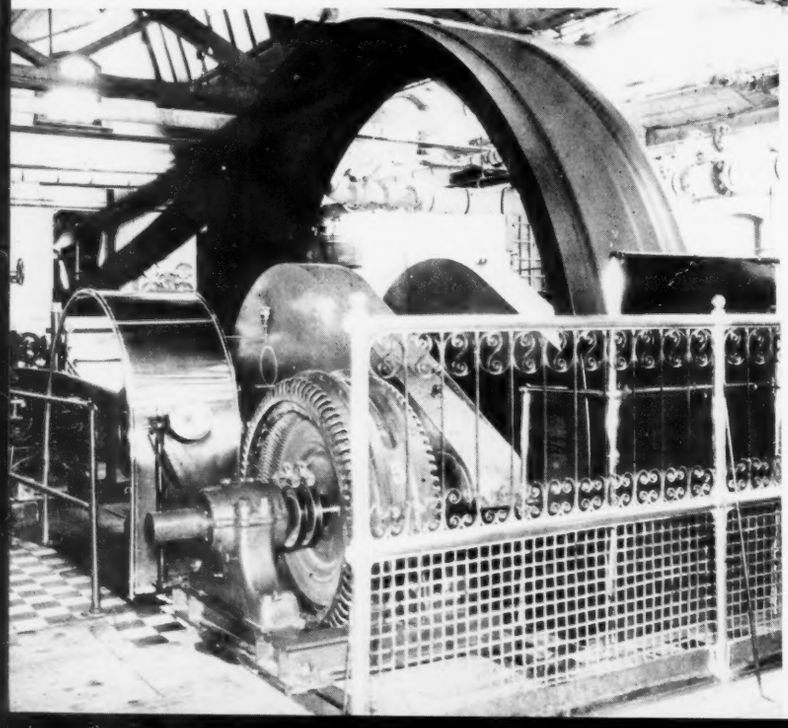
This pulsating driver, a 100-hp. gasoline engine, is connected to a pulsating load, a triplex plunger pump, by a silent chain which withstands these severe conditions

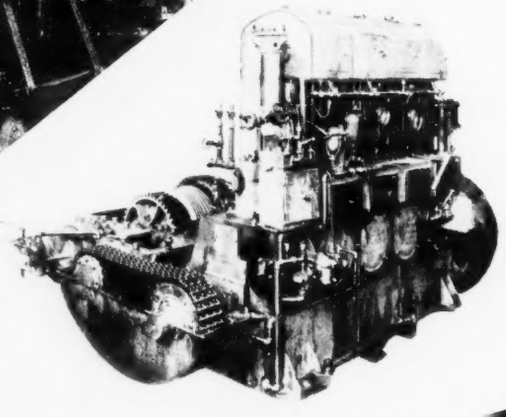




Left—To get large power in small space, chains are frequently used to drive belted group-drive lineshafts. This one powers a paper-mill beater lineshaft with 250 hp. Below center—Logging hoists are difficult drives. This one is connected to a diesel by a 3-strand roller chain. Bottom—Two medium-width chains are better than one wide one. Here two 4-strand finished steel-roller chains were selected to transmit 125 hp.

Below—Here is an interesting combination. In the small space within the engine flywheel rim, two silent chains drive a 150-kva. alternator and a 125-kw. d.c. generator. Two belts from the flywheel power group-drive lineshafts





pulsating), starting load, frequency of starting, speed of driving shaft, minimum and maximum center distances, maximum permissible sprocket size, sizes of driving and driven shafts and keyways, angle with horizontal at which chain is to operate, number of hours per day drive is to operate, atmospheric conditions (dust, moisture, acid fumes, etc.), and whether either driving or driven shaft has a flywheel. Also give principal dimensions and a sample diagram of the proposed setup—they will help considerably in visualization.

If you err in selecting drive size, be sure to err on the safe side. An oversize chain will pay dividends in satisfactory service, while an undersize one will probably be a constant source of trouble and expense. If you reduce load on a chain to 75% of catalog rating, you will double its life; if you increase load 50% above catalog rating, you'll cut drive life to 20% of what it should be.

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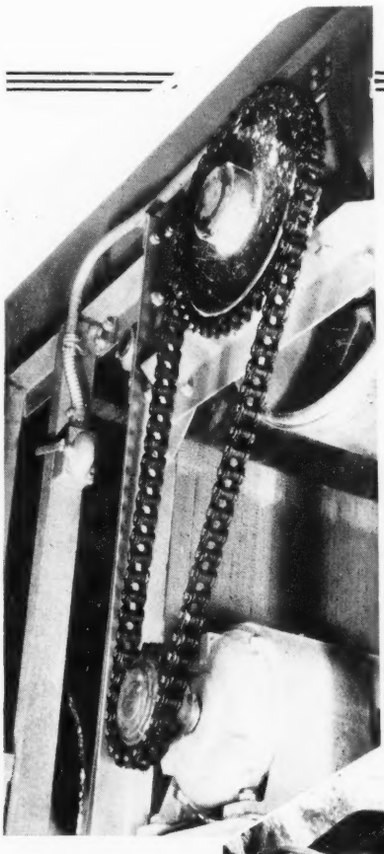
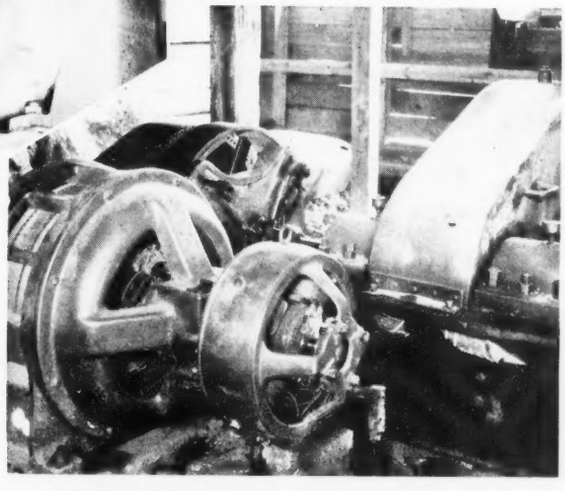
GEAR SPEED REDUCERS . . .



Left—To meet slow-speed requirements for driving this conveyor efficiently, the higher speed reduction is taken by a compact gearmotor, while the slow-speed, high-torque connection is through a powerful finished steel-roller chain



A high-efficiency, high-power-factor, 75-hp., 720-r.p.m., synchronous motor drives this slow-speed granulator in a brick plant through a friction clutch between a silent-chain and gear speed reducer

TYPES, arrangements, combinations, capacities, and speed ratios of gear reducers are almost legion. They may have spur, worm, helical, herringbone, spiral or bevel gears, in single, double or triple reductions, and output and input shafts may be horizontal, vertical, or one each way. There are also horizontal and vertical planetary types and others, including gearmotors, which combine a high-speed motor and gear in a single unit.

Worm, helical and herringbone reductions have largely supplanted the simple spur gear because they permit more teeth in contact, increasing mechanical strength, reducing shocks, and cutting noise to a minimum.

Worm gears may be single- or double-reduction units, the first inherently a right-angle drive, the second either a right-angle or parallel-input-and-output-shaft. Standard single-reduction ratios are 3.5:1 to 80:1, although they have been built for ratios as high as 100:1. Double-reduction ratios go as high as 6,400:1. Standard power-transmitting capacities run up to 400 hp. and speeds to 8,000 r.p.m., although they have been built for higher speeds. Reduction ratios may be greater than with other types; thus they have an advantage where space is limited. Although inherently speed-reducers, worm gears can be used as speed increasers where the ratio does not exceed 10:1. They usually operate in oil. Lower ratios have efficiencies as high as 97%, but for high ratios efficiency is comparatively low.

Helical, double-helical ("herringbone") gears, which have come into very wide use in preference to the old-time spur gears because of their greater strength and quietness, are built in single, double and triple reductions, for almost any capacity and pinion speeds up to 8,500 r.p.m. and more. Single-reduction ratios go as high as 10:1, double-reduction to 100:1 and triple-reduction to 1,000:1. Input and output shafts may be parallel or at right-angles and in either a horizontal or vertical plane. In right-angle drives, the high-speed reduction is usually a spiral-bevel gear. Many horizontal, parallel-shaft units have extensions so that power unit or load can be connected to either side of the gear, thus giving maximum application flexibility.

Herringbone gears are preferable to helical where

heavy shock loads must be absorbed, because they do not transmit thrust to bearings. Flexible couplings should be used each side to relieve these gears of thrust load, which may be sufficient to deflect the gear casing, overload half the gear and cause excessive wear.

Spur gears are used in both planetary and non-planetary arrangements, as are helical gears. Input and output shafts operate about the same axis in planetary types, and also in non-planetary double-reduction units. Single-reduction planetary units are limited to ratios of about 4:1 to 8:1, lower ratios causing foaming or heating of the oil and possible noisy operation. Double-reduction units go up to about 64:1 and triple-reduction to 300:1. Both planetary and non-planetary units are available in almost any size up to 200 hp. or more, depending upon speed ratio. Right-angle planetary units use a bevel or spiral gear for the high-speed reduction and are built for ratios up to 3,000:1.

The last ten years have brought tremendous advances in motorized gear speed-reducers, now generally called motoreducers or gearmotors, which combine motor and speed reducer in a unit. For single reductions the motor supports the gear, for double and triple reductions the gear case supports the motor. Straight-through or offset-shaft arrangements may be had, some of the offset-shaft arrangements having an output shaft which can be set in any one of four positions spaced 90 deg. apart.

Driving elements of these units are usually standard 1,750-r.p.m. motors. Single-speed units are standard in sizes to 75 hp. with output shafts speeds of almost any value and either horizontal or vertical arrangement. They combine a high-speed, high-efficiency high-power-factor motor and a high-efficiency gear in minimum space. Thus in Table II, a 10-hp. gearmotor is only 1 in. longer than a 10-hp., 1,750-r.p.m. motor alone. For a speed ratio of 3:1 the gearmotor is only 27 in. long and weighs 365 lb., while a 570-r.p.m. motor for direct connection is 33 in. long and weighs 560 lb., 6 in. longer and more than half again as heavy as the gearmotor.

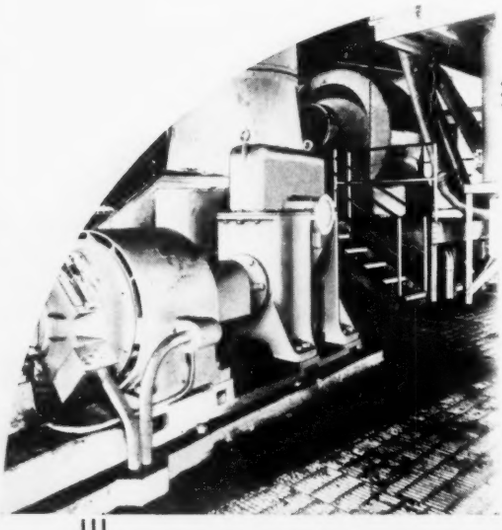
With a gearmotor, almost any output speed can be obtained, while with direct-connected motors, only a few fixed speeds are available, such as 1,750, 1,160, 860 and 690 r.p.m. If ratio is 2:1 or more, the gearmotor usually costs less and has smaller dimensions than a direct-connected motor for the same output speed.

Multi-speed squirrel-cage motors are sometimes used with a multi-speed gear. For example, a 2-speed motor and a 2-speed gear are combined to give output speeds of 49, 32, 24, and 16 r.p.m. Multi-speed gear units are also available that give four speeds when driven by single-speed motor.

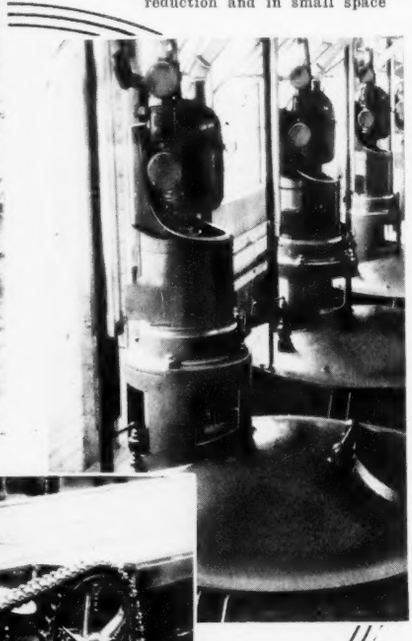
Keep in mind the method of rating gear speed reducers when you select them. Many gears are rated according to the American Gear Manufacturers' Assn. formula, others provide for operation under 100% momentary and 25% continuous overload, still others use service factors of 1 to 2 (depending on kind of load) on motor horsepower to get gear capacity. As with other types of transmission units, data books and engineering service are available.

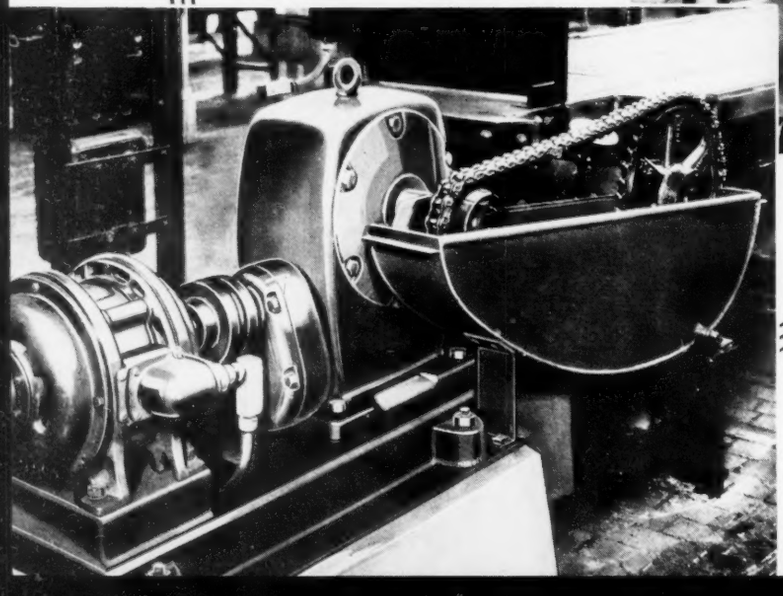
Speeds and Power Ratings of Gear Units

Gear Type	Gear Reduction	Input Speed Range, R.P.M.	Speed Ratios	Horsepower, Range
Horizontal Worm	Single	8,500 to 100	3.5:1 to 80:1	Fractional to 400
	Double	8,500 to 100	12:1 to 6,400:1	10 to 50
Vertical Worm	Single	8,500 to 100	3.5:1 to 80:1	Fractional to 200
Helical & Worm	Double	1,750 to 575	3.5:1 to 450:1	Fractional to 50
Helical or Herringbone	Single	8,500 to 1	1.2:1 to 10:1	Fractional Up
	Double	8,500 to 1	11.5:1 to 70:1	Fractional Up
	Triple	8,500 to 1	80:1 to 350:1	Fractional to 300
Horizontal Planetary Helical or Spur	Single	1,750 to 300	3:1 to 8:1	Fractional to 300
	Double	1,750 to 300	10:1 to 64:1	Fractional to 200
	Triple	1,750 to 600	70:1 to 500:1	Fractional to 30
Gearmotors, Horizontal or Vertical	Single	1,750 to 850	1.2:1 to 12:1	Fractional to 75
	Double	1,750 to 850	11:1 to 140:1	Fractional to 75
	Triple	1,750 to 850	100:1 to 300:1	Fractional to 75



Left—A 32.5:1 ratio worm gear connects a 60-hp., 860- to 430-r.p.m. motor to a coal conveyor, giving large speed change in one reduction and in small space



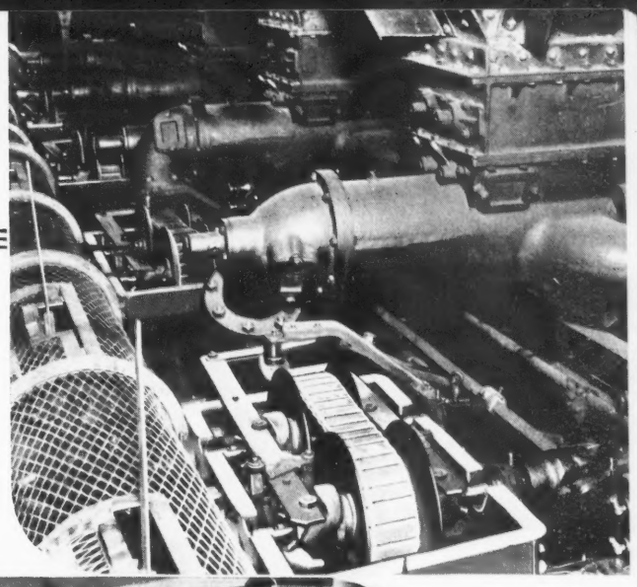


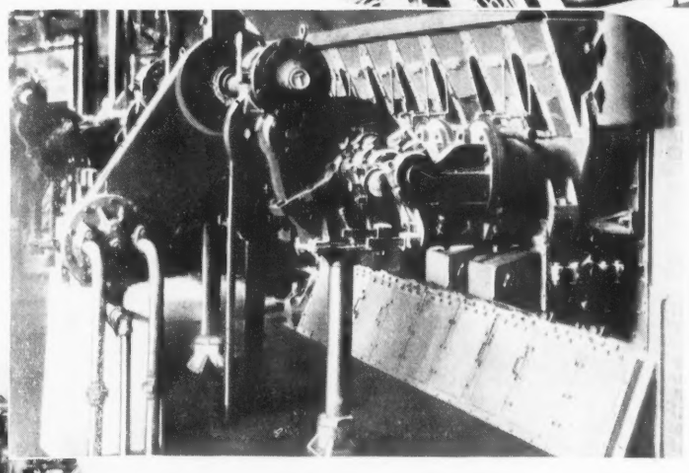
Above—Space for the power unit is very limited atop these paint mixers, so 3-hp., 1,750- to 180-r.p.m., vertical gearmotors are used. Left—This apron conveyor needs only 4 r.p.m. for its drive shaft, obtained from a simple, high-efficiency 1,750-r.p.m. motor through a helical and worm-gear combination with finished-roller steel chain taking the high-torque reduction

SPEED CHANGERS . . . .

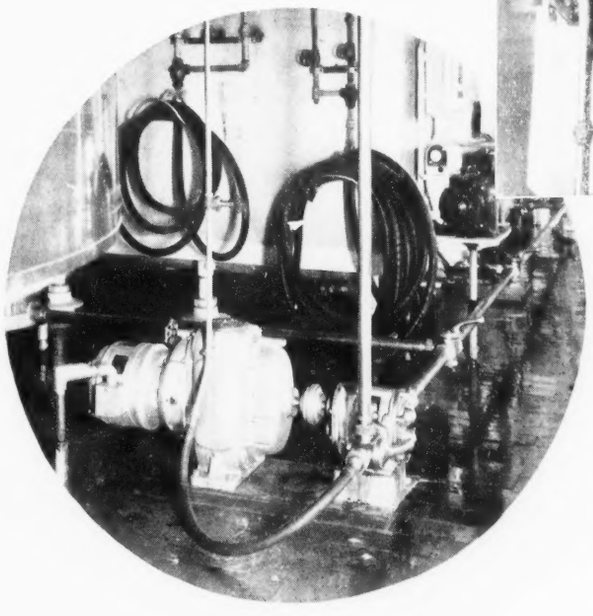
MANY times, speed adjustment is necessary in a drive, for example on pumps, fans, stokers, pulverized-coal feeders, conveyors, paper machines, textile machinery, cement kilns, rubber-calender trains, brick machines, and so on. How can this be obtained most economically?

Where direct current is available, an adjustable-speed motor often will meet all requirements. In small applications requiring wide speed ranges, a constant-speed motor with some form of variable-speed transmission is more economical. Synchronous and induction motors are essentially constant-speed machines, so where a.c. only is available, a simple constant-speed induction motor with a multi-speed or variable-speed transmission will take care of most small- and medium-power applications most economically. This is becoming even more true as transmission units become more highly developed.





Above—Pulverized-coal feeders require exact speed adjustment over a wide range, so a simple, constant-speed, a.c. motor and a variable-speed transmission are used. Left—Stokers require a positive drive for high torque over a wide speed range, here met by a hydraulic variable-speed transmission giving 20:1 speed control



This small milk pump requires speeds over a 5:1 range. A 1½-hp., high-speed, squirrel-cage motor built into a vertical, geared, variable-speed transmission does the trick efficiently, giving output speeds of 380 to 77½ r.p.m.

If you select a constant-speed, squirrel-cage motor with mechanical power transmission, you can select the most economical speed for motor size and highest efficiency and power factor without restriction. Motor speed reducer and variable-speed transmission can be built into a single unit, which with its control may occupy less space than an adjustable-speed or multi-speed motor and its control.

Wound-rotor induction motors may be slowed down to about 50% of rated speed by connecting resistance in the rotor circuit. In applications where load decreases rapidly as speed is reduced, this type has an economic place. Equipment is comparatively expensive, efficiency is low at low speeds, however, so for most uses the simple constant-speed squirrel-cage motor is preferable.

Multiple-speed induction motors may have two to four speeds, such as 600, 900, 1,200 and 1,800 r.p.m. Polyphase commutator-type motors are built for adjustable-speed applications, but are complicated and expensive in first and maintenance costs. Variable-voltage control equipment may also be used, but is usually economical only for medium and large power applications.

Several variable-speed transmissions, either mechanical or hydraulic types, give an infinite number of speeds between set maximum and minimum values. Mechanical types use such devices as sliding friction disks, flat belts on two opposed parallel-cone pulleys, V-belts on adjustable-V pulleys, planetary conical-shaped rollers, tilting-disks driving variable-throw eccentrics or other mechanical movements such as sliding links and gears, and multi-speed gear units giving two or more speeds through a gear shift. Compact units of the latter type combine a high-speed squirrel-cage motor and a gear unit to give four speeds.

Hydraulic types combine a variable-displacement pump and a constant-displacement or variable-displacement fluid motor. These are of the positive type and will give a constant output speed for a given control setting irrespective of how the load changes, so long

as input speed is maintained at constant value.

Hydraulic couplings, used particularly for loads such as fans and pumps, have no mechanical connection between input and output elements. The driving end of the coupling acts as a pump to deliver fluid to the driven end, which in turn performs as a waterwheel to drive the output shaft. The driving fluid, oil, is circulated continuously through the coupling, output speed being regulated by control of oil flow. Efficiency of a hydraulic coupling decreases directly as the slip. On fans and pumps, the power saving when operating at reduced speeds greatly outweighs any loss that may be caused in efficiency.

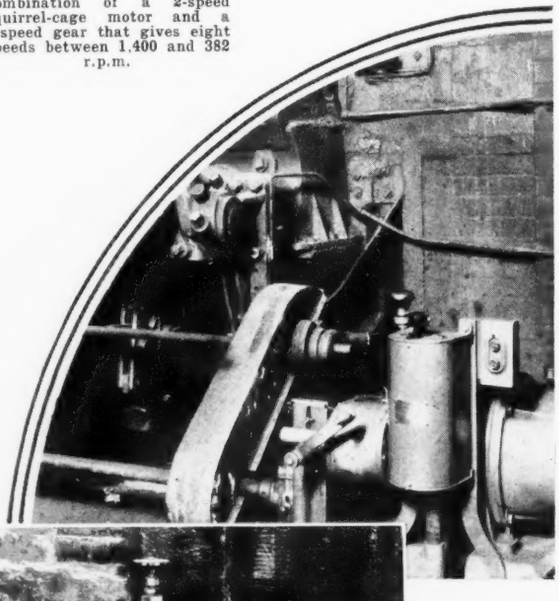
Compact combinations of speed reducer and variable-speed transmission will give almost any output speed. For example, with a 1,800-r.p.m. motor, output-shaft speed may be 30 to 480 r.p.m. Maximum speed reduction is 60:1, output speed range varies from 16:1. Others will operate down to zero speed and reverse. Other designs are available in sizes up to several hundred horsepower and a wide speed range. Transmission efficiency varies with type and speed range. Some types have full-speed efficiency of 95%. As output-shaft speed is reduced, load and efficiency also decrease. Hydraulic-type efficiencies will run from 80 to almost 90% over a wide range when driving constant-torque loads.

Don't judge variable-speed transmissions by efficiency alone. Take into account also such factors as first cost, operating cost, speed-range control, and adaptability of the unit to its job. Don't overlook the fact that adjustable-speed motor efficiency decreases as its speed goes down, for example efficiency of a wound-rotor motor decreases almost directly with speed when driving a constant-torque load. If you buy power, the lower power factor of certain types of a.c. motors operating at reduced speed may seriously increase your power costs.

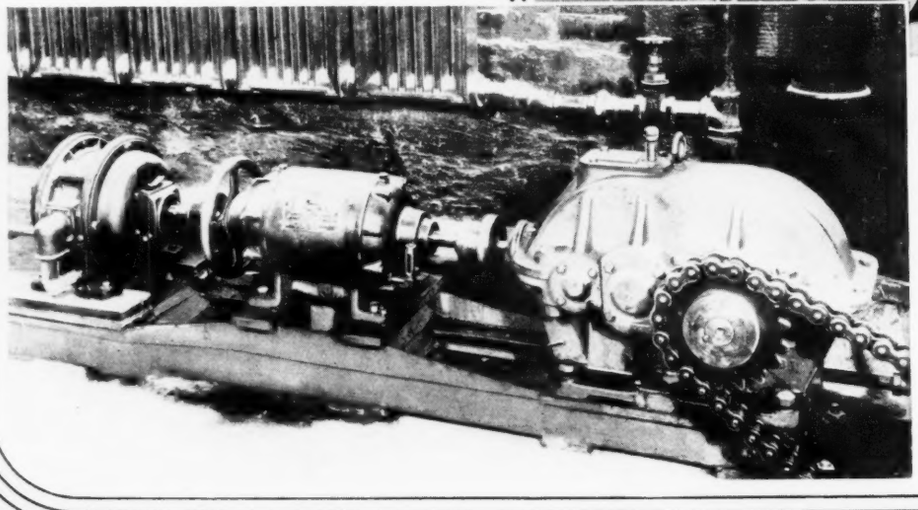
Control for variable-speed transmissions may be manual, remote or automatic. Speed, adjustable over the full range in an infinite number of steps, remains constant for each adjustment regardless of load. With some types of variable-speed motors, speed adjustment is limited to the number of steps in the controller, and speed remains constant for any setting only when load is constant.

When you select a variable-speed transmission, you must know: kind of machine to be driven, and its maximum and minimum input-shaft speeds, if reversing is required maximum and minimum speed in each direction and frequency of reversal, method of starting and stopping, heavy or light starting duty, whether running load is steady or intermittent or pulsating, maximum torque and at what speed, maximum horsepower required at maximum and minimum input-shaft speeds, number of hours operated per day, how input shaft is driven (flexible coupling, flat belt, multiple V-belt, chain or gear), dimensions of drive, location of transmission relative to driven machine, motor horsepower, type and speed if transmission is to be motor-driven, how transmission will be mounted (floor or ceiling, vertically or horizontally), space limitations, unusual operating conditions (dust, fumes, moisture, very high or very low temperatures), speed-control requirements (degree of accuracy to be maintained, synchronization of speeds, or other limitations), type of control needed (manual, remote manual, remote electrical, full-automatic electrical or mechanical, time-cycle control for continuous or intermittent speed changes).

Variable-speed transmissions vary so widely in types of construction, operation, range of sizes and speed adjustment that it is almost impossible to provide general specifications for their selection. But consider every one of the factors in the preceding paragraph, then if you must take a chance, take is on the safe side. Usually, however, this is not necessary, for engineering data and consulting service are available from transmission-equipment builders.



Right—Speed of this stoker is adjusted in steps by a combination of a 2-speed squirrel-cage motor and a 4-speed gear that gives eight speeds between 1,400 and 382 r.p.m.

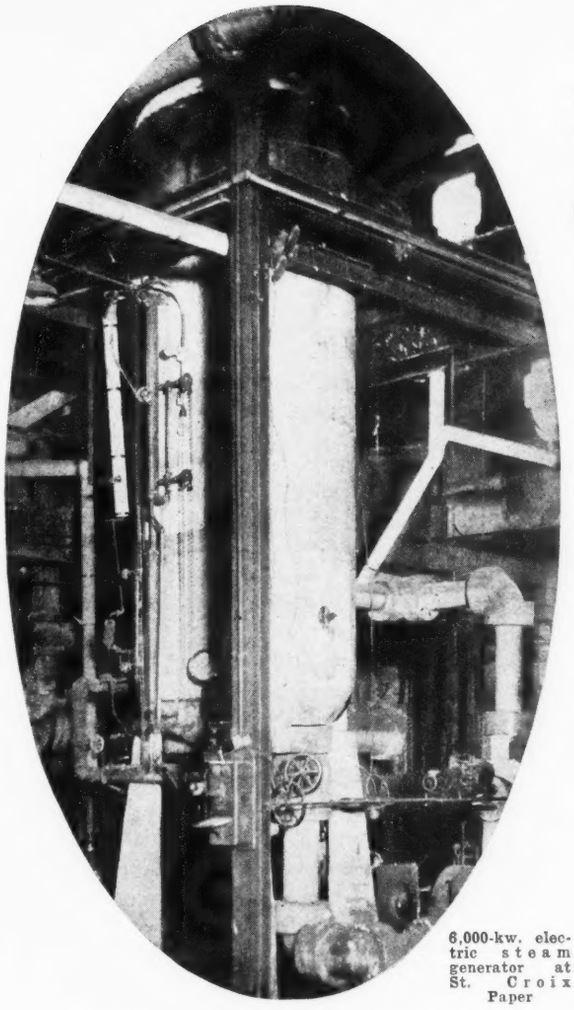


Talk about speed reduction and control! Here it is — this assembly conveyor is driven at 0.25 to 1.25 f.p.m. from a 1,750-r.p.m. motor through a variable-speed transmission, triple-reduction helical gear, and a finished steel-roller chain taking the slow-speed, high-torque reduction

ELECTRIC BOILER Cuts Heating Costs

By John P. Topolosky

Steam Engineer
St. Croix Paper Co.



6,000-kw. electric steam generator at St. Croix Paper

ELECTRIC steam boilers are used extensively to utilize power from hydro-electric plants at times when the water otherwise would run to waste, such as during high water, over week-ends and holidays. We have worked out a system of operation in our 200-ton newsprint pulp and paper mill at Woodland, Me., whereby our electric steam boiler can be used economically during periods when the river is under control and it is desirable to hold water in storage.

Power at this mill is supplied by two hydro stations and a steam plant. The latter comprises a 450-lb., 7,430-sq.ft. boiler, two 110-lb., 7,490-sq.ft. boilers, all pulverized-coal fired, one 8,430-sq.ft., 110-lb., stoker-fired boiler, a refuse-fired boiler with 3,140 sq.ft. of water-heating surface, one 6,000-kw. electric steam boiler, two 450- and one 475-hp. geared steam turbines driving paper machines, a 3,750- and a 600-kw. turbine-generators. In addition there are thirteen small turbines in the plant, most of them on mill-heating units.

Up the St. Croix river 11 mi. above the mill, a 9,000-kw. hydro-electric plant supplies power to the mill over a 33,000-volt transmission line. At the mill itself is a 2,200-kw. hydro plant. Sixteen of the wood grinders are driven by waterwheels, nine by electric motors. During high water, both hydro plants are operated, all power requirements and part of the steam being supplied by them.

When river flow is under control, only the upper plant is operated and loaded to supply water for the grinders and for process. Pond level at the mill is maintained near maximum by changing from waterwheel to motor-driven grinders, or vice-versa. If pond level begins to drop, a waterwheel-driven grinder is shut down and a motor-driven one started. This reduces water demand at the mill and increases it at the hydro plant. The opposite process is followed when pond level rises above the permissible maximum.

The electric boiler, originally installed to utilize excess hydro-electric power during high water, is also used now when the river flow can be controlled, to permit the steam plant to shut down week-ends.

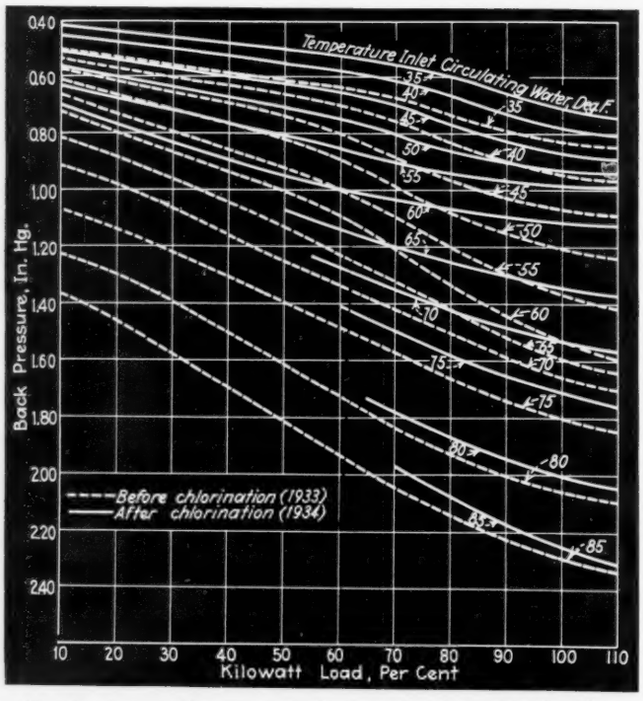
Before we installed the automatic heating-system control, described in January *Power,* it required about 100 tons of coal to maintain steam pressure and supply steam for heating and other purposes over Saturday and Sunday. Now by generating about 200,000 kw.-hr. extra with steam during the week, which can be done with the high-pressure turbine from about 30 tons of coal (4,000 B.t.u. per kw.-hr.), load can be reduced on the hydro plant and the water stored. Then over the week-end this water is used in the hydro plant to generate power for the electric boiler while the coal-burning plant is shut down. This operation, combined with automatic heating-system control, saves about 100 — 30 = 70 tons of coal each week-end when there is not an excess of water.

This is an unusually interesting application of an electric steam boiler to save fuel. It shows that such a boiler may have an important place in power-system operation in low-water periods as well as in high-water seasons. In this particular case the hydro plant has to be operated over the week-end to supply the town lighting load and power for other small services. Consequently, it costs practically nothing to produce the power for the electric steam generator, other than the cost of coal. Operation of the electric boiler also reduces the amount of labor necessary to keep steam on the plant over the week-end.

TO SAVE, CEDAR RAPIDS TREATS BLOW-OFF, BOILER WATER, COOLING WATER

By W. L. Starkweather

Chemical Engineer,
Iowa Electric Light & Power Co.


Temperature Inlet Circulating Water, Deg. F.
Back Pressure, In. Hg.
Kilowatt Load, Per Cent
Before chlorination (1933)
After chlorination (1934)

Condenser performance before and after chlorination

IF A cooling liquid is to be effective, the prime requisite is a minimum resistance to heat transfer from the substance cooled to the cooling agent. It has been established that heat-transfer resistance of metal is practically nil as compared to resistance of gas and liquid films on the surfaces of the metal. Very thin layers of scale also present far more resistance than does the metal. Coatings of slime also increase enormously the resistance to heat transfer.

It follows, then, that to obtain the best results in cooling by water we should keep the metal free from scale and slime, obtain higher velocities of liquid to sweep thinner the stagnant film on the metal surface, and have the incoming cooling water meet the outgoing cooled substance (a counter-current cooling system).

All water used at the Cedar Rapids power station is taken from a lake about 60 acres in area and normally about 6 ft. deep. Temperature ranges from 33 deg. in winter to 90 deg. in summer, and hardness ranges from about 7 g.p.g. (grains per gallon) to about 14.

This water in the spring and summer is heavily infested with algæ and bacteria, and these caused rapid and heavy growths of muddy slime on all surfaces in contact with the cooling water, which necessitated the cleaning of these surfaces at intervals of 14 to 18 days in summer and slightly longer in winter.

Early in 1933 several tubes were removed from one of the condensers for inspection. Supposedly, the steam side of the tubes was clean, but on this side there was found a thin, brown, scaly deposit probably from occasional slight carryovers of boiler water in the steam.

All condenser tubes were cleaned on the steam side with a prepared acidic liquid[1]. The discharge of the hotwell pump was removed and replaced by a pipe leading to the upper part of the condenser. Diluted cleaning liquid was placed in the shell of the condenser until the tubes were well covered. It was then circulated by the hotwell pump to obtain a higher velocity and at the same time heated by a steam coil in the condenser to obtain quicker cleaning. Dilution of the liquid retained its cleaning action and prevented harmful corrosion of the tubes. After this scale removal there was a drop of 4 deg. in temperature difference between exhaust steam and outgoing cooling water.

At this time it was decided to chlorinate the water, and in the late summer of 1933 two Wallace & Tiernan 720-lb. capacity chlorinators were installed. Since a continuous feed of chlorine would be far too expensive, the intermittent feed was decided upon. By means of a 3-hr. Telechron dial, motor-operated valves, and several combinations of disks in sets of two, chlorine feed could be adjusted as to intervals between operations and to length of dosage. The chlorine dose is maintained heavy enough to satisfy the chlorine demand of the water and provide an excess of about 0.2 p.p.m. free chlorine at the end of the first pass.

In three months the condenser tubes and all the cooling system were entirely free from mud and slime and have remained so. Since installation of the chlorinators, no tubes have been cleaned manually. Back pressure on one of two 10,000-kw. turbine-generators has been lowered 0.1 in. on 35-deg. cooling water and 10% load and 0.5 in. on 60-deg. cooling water and 100% load. On one 10,000-kw. unit alone this has resulted in a saving in steam cost of from $125 to $200 a month. The diagram is a graphical representation of condenser performance before and after chlorination. Periodical cleaning has been eliminated, and water pumpage has been reduced. Monthly cost of chlorine varies from $20 in winter to $80 in summer.

Treatment of boiler water consists of addition of $1\frac{1}{2}$ g.p.g. of aluminum sulphate, filtration by pressure sand filters, addition of $1\frac{1}{6}$ g.p.g. of sodium silicate, and softening by zeolite. In past years a continual heavy loss of zeolite from the softener was noted. The cost of replaced material alone ran as high as $500 or $600 a year. Decreased capacity due to shortage of zeolite necessitated more frequent

[1]Dearborn Chemical Co.'s Formula No. 134

regenerations and consequently a greater consumption of salt. It was occasionally necessary to spade over the zeolite bed to remove mud balls (accumulations of mud and fine zeolite) which caused packing of the bed and water channels through the zeolite.

The trouble was finally traced to a particular group of algæ contaminating the source of water supply. This group, crenothrix, tends to form iron and manganese. Considerable iron and manganese will be found in the sheaths of these organisms. Other microscopic organisms, such as diatoms, contain considerable silica. It was natural to assume that the algæ and diatoms extract these constituents from the zeolite, thus destroy the structure of the grains and form fines (smaller than 60 mesh). These fines then are washed away on the backwashing of the softeners.

Chlorination of the filter and zeolite beds was deemed too expensive, accordingly it was decided to try the aluminum-sulphate and sodium-silicate feeds. The alum was to coagulate dirt and bacteria, the floc to be retained on top the filter beds and subsequently removed on backwashing the filters. Sodium silicate was to be fed to the filtered water to aid in keeping the zeolite grains intact and protect the bed from algæ action that might be carried into the softeners.

First installation of alum-feed treated the raw water as it was entering the filters. This was unsatisfactory, since even with an alum feed of 3 g.p.g. of water no appreciable floc was formed above the filter bed and most of the chemical remained in solution long enough to flocculate at various points beyond the filters.

Laboratory tests showed that with no agitation beyond the original mixing of alum solution with raw water, 3 g.p.g. formed no noticeable floc in 10 min.; but addition of 1½ g.p.g. plus agitation for 1 min. thereafter, produced a desirable floc in ten minutes. With this established the alum feeder was moved back on the raw-water line far enough so that at maximum rate of flow at least 1 min. would elapse before the treated water reached the filters, the water having passed several turns and fittings to fulfill the provision of agitation. The latter arrangement proved satisfactory and produced a filtered water showing over 90% removal of solids and organisms, no trace of alum still in solution, and a turbidity of not over 1. An alum feed of 2 g.p.g. produced about 99% removal of solids and organisms. In a year of operation there has been very little loss of zeolite and near rated capacities have been maintained. Alum treatment also has brought the sulphate-alkalinity ratio to about 2.5:1 which is well within A.S.M.E. specifications for the operating pressure of the plant.

Because a certain amount of organic matter does escape the filters, and accumulates and grows in the softener beds, it was thought advisable to sterilize the beds frequently. Use of hypochlorite compounds to accomplish this was found quite expensive, as the cost per pound of available chlorine varied from $0.40 to $0.60.

If a test set-up of a 12-lb. capacity chlorinator, now in operation and using pure chlorine at $0.08½ per lb., proves satisfactory, which it shows every sign of doing, it will be replaced by a permanent installation. The equipment chlorinates the backwash of the softeners and filters. Beyond first cost, the cost of operation will be very slight, with not more than $0.0002 or $0.0003 added per 1,000 gal. of conditioned feedwater.

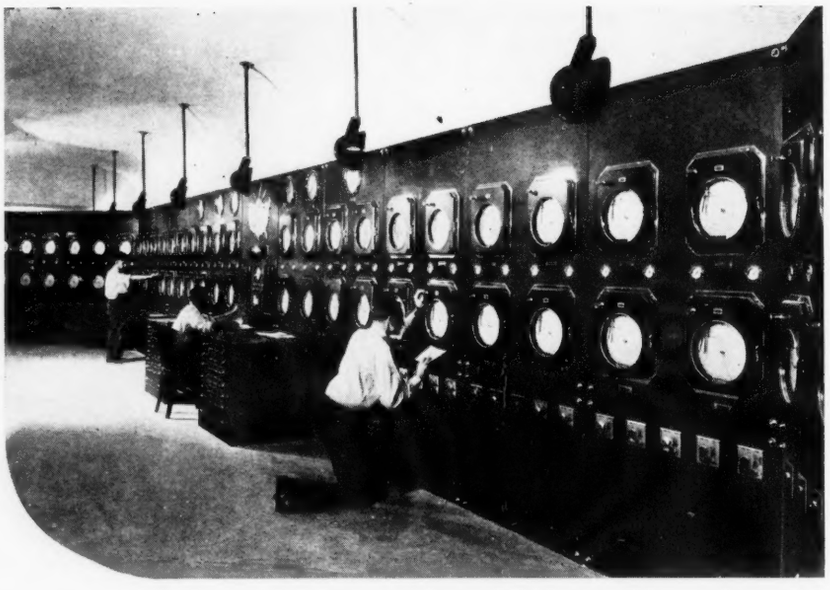
Our boiler plant is equipped with a continuous blow-off system, blow-off water being used to heat the incoming feedwater. Boiler concentrations are kept at approximately 120 g.p.g. total solids, and are checked daily by a chloride test of the concentrates. With this system, the concentration of 120 g.p.g. is held very closely. At present there is under way the installation of a flash tank and flash condenser for the blow-off system. By flashing the blowoff from 210 lb. per sq.in. to 30 lb. per sq.in., steam equivalent to 360,000 kw.-hr. a year will be recovered.

THE BRICKLAYER'S GLOSSARY

READERS have requested an explanation of bricklaying terms used in the Refractories Section of POWER in September, 1935. Here it is, through the courtesy of H. T. Webster and the New York "Herald Tribune." "Balloons" were written originally by the POWER editorial staff bricklayer, E. J. Tangerman.

They Don't Speak Our Language — BY WEBSTER

SLOW DAY T'DAY. ONLY LAID 3 COURSES OF STRETCHERS AN' ONE OF HEADERS. MORTAR WASN'T TEMPERED RIGHT AN' HAD T' TAKE DOWN A BAD TOPPIN' OUT JOB OVER A GLIM. GOT SOME CURTAIN WALLS T'MORRA, COMMON BOND, I GUESS
HOW 'BOUT THAT FRAME OUTA PLUMB?
OH, WE HAD TO TAKE DOWN THE SKEWBACK AND RESET THE LINTEL, TH' WALL WAS RACKED AN' TH' BOND WAS BAD IN PLACES, SOMEBODY USED BATS AN' SOLDIERS IN TH' WRONG PLACES AN' IT WAS HOGGED ON TOP. SOME OF THEM BOYS DON'T KNOW TH' DIFFERENCE BETWEEN A SOAP AN' A BLIND HEADER
SOME OF THEM BOYS CAN'T EVEN SET ROWLOCKS
THAT'S RIGHT. THEY DON'T KNOW TH' DIFFERENCE B'TWEEN PARTY WALL AN' GABLE-END BLOCKIN'. ASK 'EM WHAT A CORBLE IS AN' THEY DON'T KNOW, AN' THEY'RE DUMB ENOUGH T' USE A SKUTCH T' SPLIT FACE BRICK
WHY DON'TCHA SET 'EM AT CUTTIN' KINGS?
NO CHANCE, SAY SOMETHIN' 'BOUT 3-COURSE BLOCKIN' AN' TOOTHIN' AN' YA SCARE 'EM T' DEATH. NEVER HEARD OF IT
WELL, FERGIT IT. LE'S LAMP A MOVIE. WITH TH' BAKERS
WHAT! THEM FOLKS? ALL THEY KNOW IS HAIRCUTS AN' SHAMPOOS — CAN'T TELL A COURSIN' POLE FROM A SINGE, NAH, THEY DON'T SPEAK OUR LANGWICH!
E.J.T.
GLOSSARY OF BRICKLAYER TERMS
COURSES ..... THE HORIZONTAL LAYERS OF BRICK
STRETCHER ..... A BRICK LAID AS THE WALL RUNS
HEADER .... A BRICK LAID IN DIRECTION OF WALL THICKNESS
TEMPERING ... WORKING MORTAR
TOPPING OUT .... CLOSING OPENING AT TOP OF DOOR OR WINDOW
CURTAIN WALL .... WALL BETWEEN STEEL FRAMING
BAT ..... HALF A BRICK
COMMON BOND ... 5 COURSES OF STRETCHERS TO 1 OF HEADERS
SOLDIER ... BRICK SET ON END
RACKING ... DISTORTING WALLS WITH BEAMS
SOAP KINGS ... A BRICK CUT IN HALF LENGTHWISE
SKEWBACK ... COURSE FROM WHICH AN ARCH STARTS COMING TO A HEIGHT
HOG ... A COURSE OF BRICK DIFFERENCE IN LEVEL IN
SKUTCH ... TOOL FOR CUTTING FIRE BRICK
ROWLOCK ... BRICK SET ON EDGE
BLIND HEADER ... TIES IN FRONT WORK OF A BUILDING WITHOUT METAL TIES
CORBLE ... FIRE STOP
COURSING POLE ... ROD USED TO GET COURSES UNIFORM



Control panel for regulating temperatures in the air-conditioned Radio City studios of N.B.C.

By R. B. Purdy
Associate Editor

HOW TO OPERATE

An Air-Conditioning System

EVERY air-conditioning system, no matter how like other systems in design, has its own peculiarities. For satisfactory operation with respect to economy, comfort or process control, the engineer must study the system in his charge so that he knows all its characteristics. Among the factors that give character to each system may be listed rate of heat gain or loss, individuality of tenants in the case of office buildings, periodic heat loads, open doors or windows, amount of dirt in air, type of refrigeration, source of water, etc. Because of these, operation of plants varies in many respects.

But air-conditioning systems are really an assembly of many familiar elements. Operation of each as an individual element is well understood by most operators. Take fans for example. About the only operating attention required is regular inspection to see that both fan and drive bearings are properly lubricated. In some industrial plants, fans must handle very moist air. Under these circumstances, fans should be watched for corrosion, for after it has started it is difficult to make protective paint stick to the corroded metal. Any of a number of protective paints is effective if applied when the surface is clean.

In practically all air-conditioning systems, fans are operated by constant-speed motors so that only starting and stopping is required. They should be shut down as soon as air conditioning is not required and started up enough ahead of time to have the space at the desired condition before occupancy.

Like fans, the air washer requires little operating attention other than regular inspection to see that all spray nozzles are operating properly and not clogged with dirt, that pump strainers are clean, that the circulating pump has proper lubrication and that shaft packing is in good condition. Sometimes corrosion troubles are encountered. To offset this, the water should be maintained at a pH not under 8.5. No set interval for cleaning the water tank or nozzles can be given, as it depends upon the amount of the dirt in the air handled. This is also true of air filters, which, however, should be cleaned or replaced when their resistance to air flow increases enough to interfere with the air supply (usually an increase in resistance of 0.15 to 0.20 in. water. In many instances it is necessary to clean filters only two or three times a year.

Most refrigeration plants for air conditioning are well provided with automatic controls, nevertheless, except the small units, they require considerable operating attention. Attention required varies greatly with the type of refrigeration installed—obviously a steam-jet vacuum plant is operated differently from an ammonia or Freon plant.

In all types of plants it is important to regulate refrigeration to meet the load, otherwise power will be wasted in maintaining cooling water at an unnecessarily low temperature. Manual adjustment is often required to accomplish this properly. With centrifugal and reciprocating compressors, water temperature may be allowed to vary from say 38 to 45 deg. when provision is made at the air washer for mixing refrigerated water with recirculated spray water. But better economy is obtained if the temperature is not allowed to drop below say 42 deg. With steam-jet refrigeration, however, it is customary to use a greater volume of water at higher temperature.

In starting up the air-conditioning system, some engineers claim quicker starting is obtained by placing the refrigeration system in operation first. Fans are not started until the desired cooling-water temperature has been reached and the air washer operated long enough to be cooled to the water temperature. Depending upon conditions, the system should be started

from 2½ to 3 hr. before the space is to be ready for use. Only experience with the system can determine the time required to cool a room. Recording thermometers in the return-air ducts are of great help in determining the characteristic cooling rate. Less time is required to bring a room to proper condition in winter than in summer. For example, if the air-conditioning system must be put on 3 hr. ahead of time in summer, in winter it would probably be only 2 hr. ahead of time.

The engineer should anticipate any heavy loads and adjust the thermostat controls so as to lower temperature or humidity a few degrees below requirements before the expected load comes on. For example, an auditorium or banquet hall should be a few degrees cool before the audience or diners arrive to form a reserve to absorb the additional body heat. A similar reserve should be provided in the morning and after the lunch period when air conditioning is applied to manufacturing processes.

Most systems of control provide satisfactory automatic operation during summer and winter, but between these seasons a certain amount of manual control is often required. During spring and fall operation, sometimes refrigeration is required, sometimes heat, sometimes neither. Refrigeration is required when temperature of the air leaving the washer rises above the dewpoint temperature corresponding to the relative humidity that it is required to maintain. If requirements as to relative humidity are not strict, the temperature leaving the air washer may be allowed to rise to 60 deg. before using refrigeration.

When refrigeration is used, the fresh-air and relief dampers should be set so that the minimum amount of fresh air is taken in consistent with health and odor. Observing the precaution saves considerable refrigeration. The same care should be taken in winter, with resulting decrease in steam consumption.

In some localities weather conditions make it possible to take advantage of evaporative cooling. This can be done when the outdoor wet-bulb temperature is very considerably lower than the dry-bulb temperature. Successful use of evaporative cooling requires exhausting to atmosphere most of the return air.

It is the engineer's job to set the adjustment on the various thermostats so that the desired conditions are obtained. Where conditioning is for process control, these controls once set usually need little readjustment as the conditions maintained are constant. But for comfort conditioning, desired room conditions change with outside weather, hence thermostat settings must be changed accordingly. In making these adjustments, give consideration to the type of occupancy as well as economy of operation.

Where occupancy is short, as in stores or restaurants, the difference between indoor and outdoor conditions should not be great to avoid the shock experienced on entering and leaving. When, however, occupancy is for a longer time, as in office building or factory, conditions can be kept at more nearly the optimum, decreasing the difference between inside and ouside in the morning and again in the late afternoon, thus avoiding shock to the regular occupants. By allowing relative humidity to vary with outside conditions, considerable saving in refrigeration can be expected.

AVOID WASTE IN STEAM REDUCING

By S. H. Coleman

THE usual pressure-reducing station involves a reducing valve, which may or may not be controlled by a pilot-operating device, control piping, stop valves on either side of the reducing valve, and a bypass valve to permit inspection and repair. Desuperheaters are often incorporated to hold down temperatures in low-pressure lines.

Among principal losses incidental to faulty operation of this equipment are: waste, due to faulty adjustment or mechanical condition of reducing valve and control; leakage of the valve or its bypass valve; improper functioning of desuperheaters and their control.

To avoid displacing exhaust or bled steam by introduction of live steam into the low-pressure lines when not required, give the following points frequent attention:

1. *Sensitivity of the pressure-reducing device.* Sensitivity is especially important where it is necessary to maintain a reasonably constant minimum pressure in the low-pressure lines. Unless sensitivity is maintained it is often necessary to carry an unreasonably high exhaust or bleeder pressure, with consequent waste.

Mechanical binding of valve and linkage, tight packing, faulty adjustment, dirt in control lines and control devices, mechanical wear, deterioration of diaphragms, loss of spring tension and improper lubrication are frequent causes of loss of sensitivity.

2. *Leakage when holding dead end.* Seats and disks should be inspected periodically and repaired when any sign of steam cutting appears. Leakage between valve seats and body is often a cause of waste. Control equipment and linkage should be adjusted for proper valve closure when there is no live steam demand.

3. *Bypass valves* should be checked for leakage.

4. *Desuperheaters* and their control should be given constant attention. Sensitivity of the control, without hunting, must be maintained, and water-distribution and separating devices kept in good order. Too high or low superheat will produce excessive radiation or condensation losses. Where the control functions improperly and too much water is injected at times, waste will occur, due to excessive discharge of high-temperature water from separator traps. This water may cause an appreciable loss by displacing exhaust or bled steam.

Wurts Bros.

ROBOTS

Lincoln Building, New York, installs automatic control and modernizes its heating system

WHEN the 53-floor Lincoln Building, New York, N. Y., was opened for occupancy in 1929 it had installed a standard vacuum heating system with 138,000 sq.ft. of direct radiation and 40,000 sq.ft. of equivalent indirect radiation for heating entrance halls. Radiators were all provided with thermostatic traps, and two sets of condensate return and vacuum pumps were installed.

Steam is received from the street at about 125-lb. pressure, and is reduced in the basement to 80 lb. At this pressure it is piped to two points of distribution, one on the 19th floor and one on the 56th story (three floors above the top finished floor). Reducing valves at this latter level feed the tower section of the building, from the 53rd to the 32nd floor. At the 19th floor, distribution feeds up to the 31st floor, and down to the 3rd floor. Lobby heaters and 1st and 2nd floors are fed from the basement.

The heating system soon showed certain shortcomings; one caused considerable operating inconvenience. Calls from tenants for more or less heat come into the engineer's office in the basement. To provide more or less heat in answer to tenant requests it was necessary for the engineer to send a man to either the 19th- or 56th-floor distribution room to adjust the weight on the regulating lever of the pressure-reducing valves. This trip often took considerable time, delayed answering the tenant's complaint, and took the operator away from other work.

Difficulty in steam distribution caused some loss in economy. When the upper floors of the building were heated satisfactorily, the lower ten floors were too cold. To heat these lower floors to a comfortable temperature it was necessary to overheat floors from the 10th to the 19th. Lack of heat in the lower floors was due not so much to lack of radiation on these floors as to unequal steam distribution, those radiators near the 19th floor down-feed distribution header receiving more steam than the lower radiators.

The first step taken to correct the heating system was installation of orifices at the inlets to all direct radiation. These were designed so that a pressure of 3 lb. in the system would permit sufficient steam to flow to each radiator to heat it completely. In addition, unit heaters, each with 250 sq.ft. of equivalent direct radiation, were installed in the corridors of five lower floors. These changes corrected the unsatisfactory heating of the lower floors.

The next step in modernization of the heating system was installation of Hoffman-Tallmadge control for the eight zones which were provided in the original piping. The tower section from 32nd to the 53rd floor has two zones, one for the south side and half the west side of the building, and the other for the north side and half of the west. The upfeed section from the 20th to the 31st has three zones, as has also the downfeed sections from the 19th to the 3rd floor. In this part of the building upfeed and downfeed zones supply the entire south side of the building. The upfeed and downfeed zones supply all of the north side except for the northeast wing, which is supplied by the third upfeed and downfeed zones.

Control Details

The control consists essentially of three main parts, control valves, pressure-sensitive element, and a remote control in the pump room for setting the pressure-sensitive element. Piping arrangement was such that the control valves had to be installed in the low-pressure piping, which could not be rearranged without considerable expense. A special eccentric valve body was developed (*G*, Fig. 1) which permitted the valve to be installed directly in the piping even though the valve size in each case was 2 in. smaller than the pipe line.

Fig. 5 is a cross-section of the control valve, which is operated by a heat motor consisting of a bellows surrounded by a steel case with a small cylindrical dome on top. Space between the case and the bellows is filled with a liquid, and an electric heating coil is wound around the dome. When the heating coil goes on, it heats the liquid, which expands and compresses the bellows. This, through a system of levers, controls the valve disk. The valve is provided with a spring

CONTROL HEATING

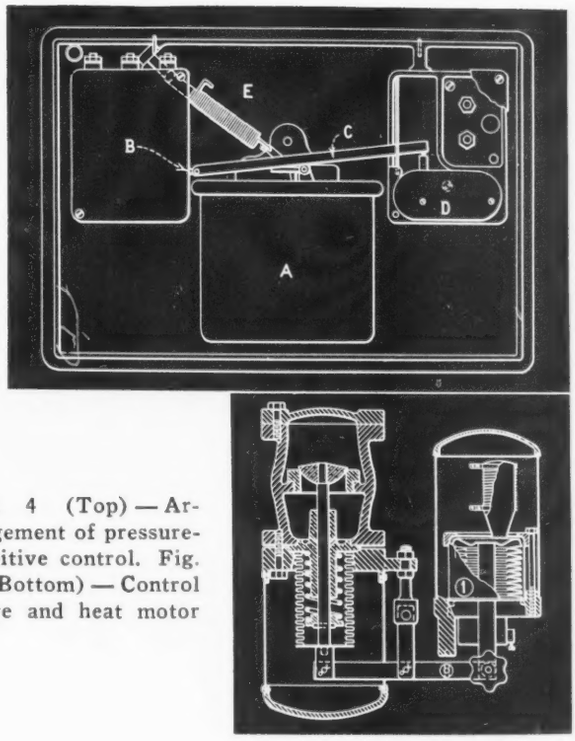
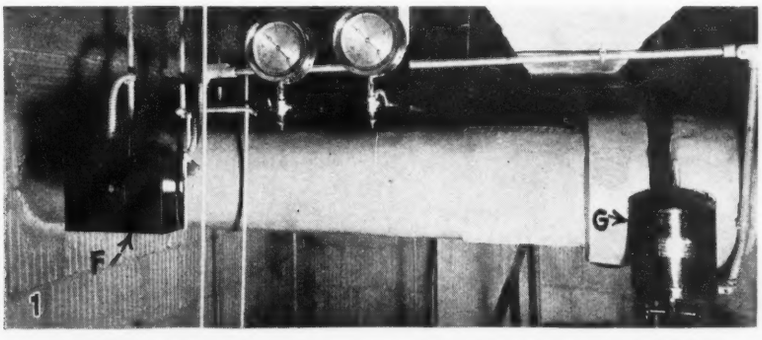
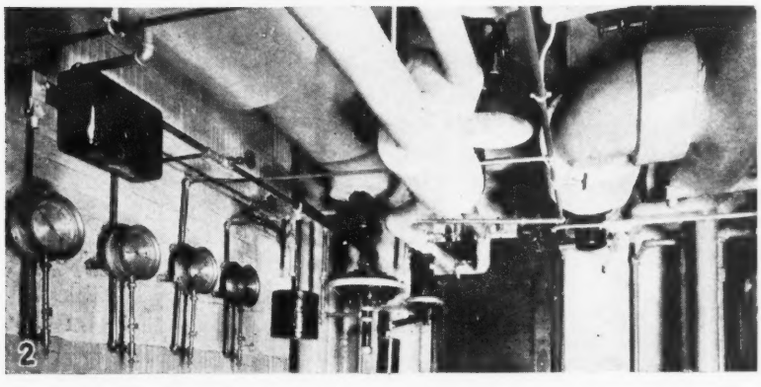


Fig. 4 (Top) — Arrangement of pressure-sensitive control. Fig. 5 (Bottom) — Control valve and heat motor

which augments the closing action of the heat motor. A second bellows takes the place of valve packing. Arrangements are provided for hand control should this become necessary.

Current to the heating coil is controlled by the pressure-sensitive element, one of which is shown at *F*, Fig. 1 and in outline in Fig. 4. A special casting connects the bellows *A* with the steam main and also holds water in the bellows to obtain sensitivity. A stem from the bellows, operating through a special toggle arrangement of levers, moves the floating lever *C* according to the pressure. One end of lever *C* operates a single-pole mercury switch, which, on closing, permits current to flow to the heating coil. At its other end, lever *C* is pivoted at *B*, which may be moved vertically by the remote-control transmitter. As *B* is moved upward, more pressure is required to open the mercury switch. The arrangement of the levers and the spring *E* are such that a change in the position of *B* will make a corresponding change in steam flow, compensating for the square-root flow law.





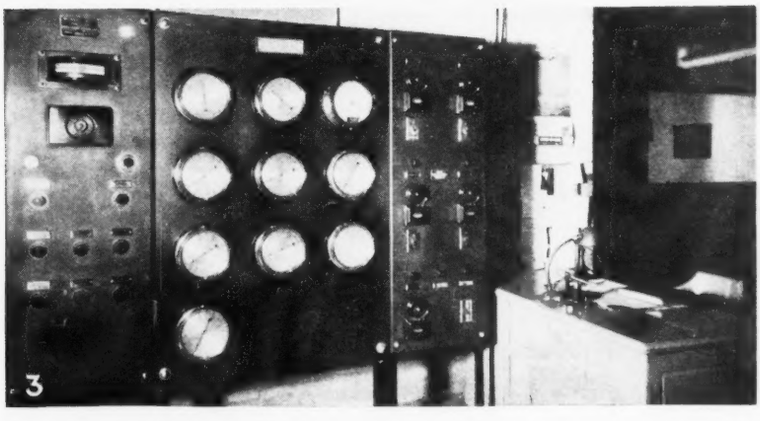


Fig. 3 shows the control board with the heating system panel at the left. The eight dials, graduated in percentage, are operated to control the steam supply to each zone by controlling the position of pivot *B* in the pressure-sensitive elements of the system. A tenant's request for more or less heat is now quickly answered by changing the setting of the control dials.

Variation in building occupancy makes it difficult to judge savings with the new system, but B. C. Corbalis, building superintendent, estimates that steam consumption has been reduced about 15%. During the 1934-1935 season (Oct. 1 to June 1), steam consumption was 37,368,000 lb., including steam for water heating.

Fig. 1 (Top)—One of the zone controls on the 19th floor. Fig. 2 (Center) — Distribution room on the 56th floor. Fig. 3 (Bottom)—Heating system control panel at left.

FEED-PUMP TROUBLES — How to

What are the causes of centrifugal boiler-feed pump troubles? Here is an analysis, with several methods of avoiding difficulties

TWO things can happen in the feed system to endanger centrifugal boiler-feed pumps: heater water level may get too low, and the water-level regulator may stop flow into the boiler. When feed pumps are operated in parallel at light loads, occasionally one pump may be backed off the line. This is the same in effect as closing the discharge line, and usually causes the rotating element to seize the stationary parts and damage the pump. A boiler shutdown may result, or, at least, the plant must be operated without a standby pump until the other is repaired.

Let us examine the real reasons back of this trouble. To maintain a reasonable efficiency in the pump, running clearances between stationary and rotating parts must be fairly close. Liquid flow through these clearances acts as a lubricant to prevent seizure.

Location

Feed pumps handling hot water must be so located that the heater maintains a positive pressure in the first-stage impeller eye. In most plants this is done by locating the heater some 20 ft. above the pump. This static head of liquid must overcome all losses due to water flow from the heater into the pump. In addition a certain minimum static head in excess of the vapor pressure must be available to get water into the first-stage impeller.

For example, assume there is 9-ft. static head in excess of all losses and that water temperature is 210 deg. F. If 8 ft. of this are required to get water into the pump at its rated speed, only 1 ft. reserve head is left to care for heater-level fluctuations. A drop in heater level of more than 1 ft. may reduce the pressure at the impeller eye below vapor pressure at 210 deg. F., and the water will flash into steam. In succeeding stages the pressure is lowered to about that in the first, and partial flashing takes place. This may result in seizure or wiping between the rotating and stationary parts due to failure of the water lubricating film.

Obviously, the remedy is a control to maintain a certain water level. If for any reason condensate or raw water fails to come to the heater, the emergency cold-water line is opened to the pump suction, and an alarm is sounded. There are objections to cold water entering the system, but, at least, it keeps the boilers full and prevents the feed pump from being damaged.

Water-Level Regulator

On the discharge side of the pump there is the water-level regulator. It is actuated by water level in the boiler drum and controls this level within close limits by increasing or decreasing the rate of flow to the boiler. The increase in flow is usually provided for in the design and selection of equipment, particularly feed pumps. These are often specified for a rated capacity about 20% in excess of the normal working load. In addition, there characteristics allow some capacity over the rating for which they are designed.

Pressure generated in modern centrifugal pumps decreases as their capacity is increased. Horsepower input to the pump becomes greater with an increase in capacity, as shown in Fig. 1. At zero capacity, power input is about 50% of that at full load. Since at zero capacity no water is flowing through the pump, the power input must be dissipated as heat to the body of water being churned around and around inside the pump casing. Since the weight of water remains constant, its temperature increases. Fig. 2 shows the relation between the power input to a pump and output as water horsepower. The difference between these, converted to B.t.u., represents the heat that must be absorbed by the water in passing through the pump. At low capacities heat to be absorbed increases, reaching maximum at zero discharge. This fact, which applies to all centrifugal pumps regardless of their size, operating speed or pressure, is largely responsible for their operating troubles.

Practical Example

For practical illustration, take the conditions with 210-deg. water and 9-ft. excess positive suction head at the pump previously mentioned. Assume the pump is driven by a 500-hp. motor and horsepower at zero capacity, or shut-off, is 150. The pump is a 3-in. unit rated at 500 g.p.m., or approximately 250,000 lb. per hr. The volume of liquid in the pump is approximately 25 gal., 208 lb. It is installed in a plant where Sunday load is very light. Under this condition, the water-level regulator may shut off water flow to the boiler for any of several reasons. The feed pump, however, continues to operate, but is discharging no water, consequently 150 hp. is being absorbed by water in the pump casing and nozzles.

Without attempting to account for every heat unit, $150 \times 42.4 = 6{,}360$ B.t.u. per min. absorbed by 208 lb. of water. Roughly, at the end of the first minute the average temperature of the water in the pump will be $6{,}360 \div 208 = 30.5$ deg. higher, or, in our case, $212 + 30.5 = 242.5$ deg. Actually it will be slightly less than this due to radiation, say 1% giving a final temperature of 240 deg. That is, the temperature would be 240 deg. provided pressures throughout the pump were sufficient. At the pump suction we have 9-ft. head, or 3.9 lb. above vapor pressure at 212 deg. F., exclusive of all losses.

Since the pump is not discharging any liquid, its suction actually has the total static head from the heater

Avoid Them

By A. H. Richards

available. Assuming this to be 20 ft., the pump suction will have 8.3 lb. pressure on it, or a total absolute pressure of 23 lb., equivalent to 235.5-deg. water. When temperature in the suction increases above this value, the continual absorption of heat would change the liquid to steam. This is the same thing that happens when heater level is allowed to get low.

With steam in the first-stage impeller-inlet passages, the pressure in this stage falls to 23 lb. Water in the next stage has its pressure suddenly lowered, and it flashes to steam and so on throughout the pump. There may not be, and usually isn't, complete flashing, as the pump generally seizes before this happens. Flashing breaks down the thin film of lubricating water between the parts and this usually causes seizure. The trouble occurs so quickly that stationary parts cannot expand as rapidly as the rotating parts because they will be heated more slowly, being of greater mass and exposed to atmosphere. Greater expansion of the rotating parts will reduce the normal running clearance and aggravate the conditions.

Remedies

Methods of preventing failures can be applied easily. They all accomplish the same thing. When the regulator closes the main discharge line, sufficient water is kept moving through the pump to prevent its temperature from reaching the flash point in the pump. Remedies suggested below, with one exception, are in use:

1. Unless the load fluctuates widely, the hand-operated by-pass valve may be left opened, allowing a given flow into the boiler regardless of regulator position. This is usually not sufficient to provide complete protection, but is an additional safeguard.

2. A line, minimum ½ in. in diameter, may be run from the pump discharge tc the heater, Fig. 3. This line can be kept open at all times, if load fluctuations are large.

3. A relief valve can be installed in this line and set to open at a pressure corresponding to low pump capacity. Adjustment must be carefully made, however, and there is always the possibility of a sticking relief valve. This is not suitable for variable-speed operation.

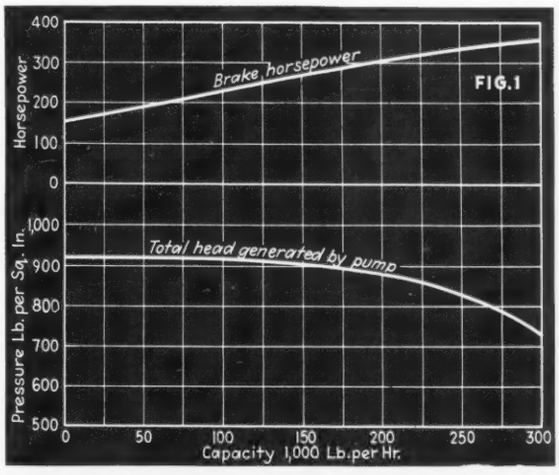
4. A clamp may be put around stem of the water-level regulator and adjusted to operate a limit switch and actuate a solenoid valve in the bypass line to the heater at minimum flow. If load fluctuations occur during weekends and nights only, the operators may be instructed to open the bypass line to the heater during these periods.

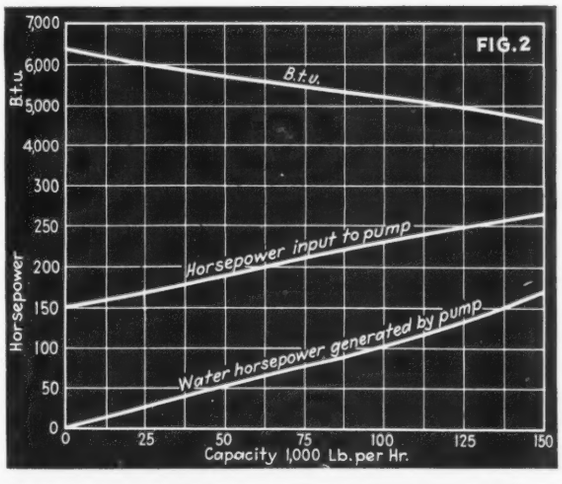
5. If the boiler-feed pump is hydraulically balanced by a balancing device within its casing, a by-pass line will connect the discharge and suction nozzle to return leakage past the balancing device to the suction. Remove this line, plug the suction connection and connect the discharge to the heater, Fig. 4, using pipe at least two sizes larger than the line removed. Leakage past the balancing drum is usually sufficient to protect the pump for a short time.

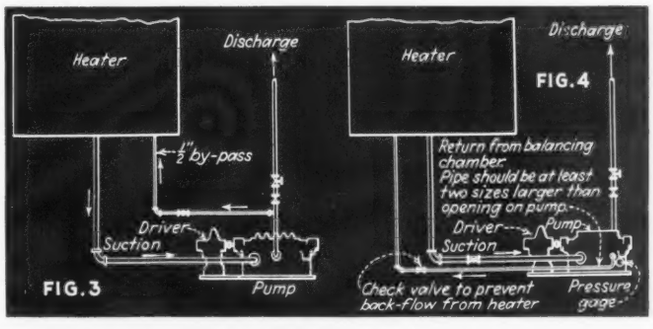
U. S. Navy regulations covering installation of boiler-feed pumps require a bypass equipped with relief valve or that the balancing line be connected back to the heater.

Every pump manufacturer is anxious that his equipment give a good account of itself. Considerable expense is incurred in dispensing engineering advice, instructions, and in many cases supervision of installation and initial operation. Full cooperation between manufacturer and consumer will insure maximum satisfaction from the equipment.

Fig. 1—Characteristic curves of a centrifugal boiler-feed pump. Fig. 2—Curves show source of heat produced with a centrifugal pump. Fig. 3—Bypass from pump discharge line to heater. Fig. 4—Bypass from pump balancing chamber to heater







PARALLEL OPERATION OF

Last month, Mr. Kice emphasized drive in fan selection. Here he shows how "humpy"—characteristic fans run in parallel

IMPROPER theory has led engineers astray mainly because of three fan characteristic curves: (1) A pressure curve that dips or waves, (2) A rising static-pressure curve, (3) A "non-overloading" power curve.

From the standpoint of the fan alone, theoretically, the proponents of compound-pressure curve, rising-pressure curve, and drooping-power curve theories are correct. Theoretically, an automobile driver would be expected to press one foot on the clutch and the other on the gas throttle and damage his engine by racing it, but practically this doesn't happen. In practice, the engine is geared to the road, hence cannot run away, and likewise an induced-draft fan is geared to a system. The load (system) changes considerably, but nevertheless it is there.

Fan-wise men know that a forward-curved fan has three points of equal pressure on its static-pressure curve and quite logically can ask why the fan in operation cannot jump from one point to the other two, especially when two fans are operating in parallel—or, in this same case, why one fan will not pick out one point and the other fan pick out the other one, both of equal pressure.

Fig. 1 shows the three points of equal pressure. Suppose a forward-curved fan is picked at point *B*. Will it jump to point *C*, or back to point *A*? Or, if point *B* represents the total volume of two fans, why will one fan not work at point *A* and the other at point *C* and then exchange places?

Curves expressing capacity, pressure, speed and horsepower are bound together for any given fan. If one alters the fan to change one curve, all the rest have to be corrected accordingly. Therefore, a fan cannot "jump" one curve without jumping all the rest. It cannot "strip gears." The static-pressure curve is only one of the "gears." There are others, such as the velocity-pressure curve, the total pressure curve, the hp. curve, efficiency curves, and various ratios of one pressure to another pressure. At a given speed and temperature, any given fan at a particular ratio of outlet-velocity pressure to total pressure will fix the operation of that fan on one point and it will stay there. Only system characteristics change fan performance.

A system change in an induced-draft fan occurs when a boiler and other equipment become more foul or clean, or through a gas-temperature change.

Theoretically, system resistance will vary as the square of flow and inversely as the absolute temperature or directly as the gas weight. Actually this might be slightly different. However, whatever the system curve is, it can be plotted. It is this system curve that sets fan performance.

In the following discussion constant temperature will be considered and the pressure will be considered as varying as the square of the gas flow. However, any other system characteristic will govern this analysis.

Considering a constant speed and temperature, Fig. 2 shows the relation of the system to the fan. The fan's ability to produce static pressure has to lie somewhere on that curve. Any relation of pressure and volume of the system must lie on line *S-S*. Where these lines intersect is the only possible point for the fan to operate. Assume this is point *B* carried over from Fig. 1.

To operate at another point, as point *C*, the system has to change as shown by line *S-S'*. For this same pressure, however, it is noted the volume has increased 38%. For the original volume, the pressure has to be decreased 49% or to point *B'*.

Thus the only way the fan at constant speed can move from *B* to *C* is for the system pressure to drop 49%. To move from point *B* to point *A*, the system resistance *S-S''* has to increase 29 times, or 2800%, represented by squaring the volume ratios at points *B* and *A*, or, $(81/15)^2$. Since it is the system that

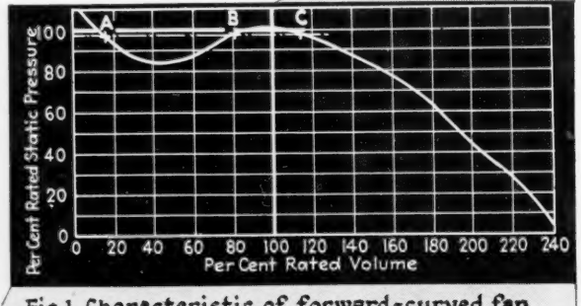


Fig.1 Characteristic of forward-curved fan

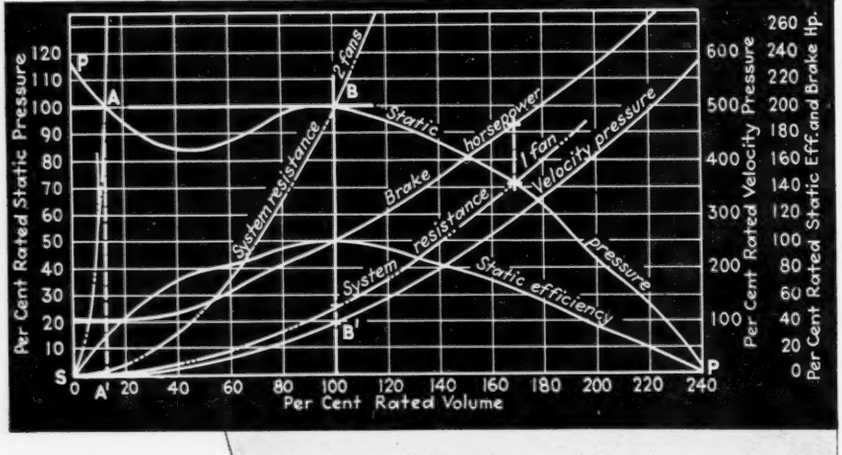


Fig.3 Two forward-curved fans in parallel

INDUCED-DRAFT FANS

By M. S. Kice, Jr.

Head, Industrial Division,
American Blower Corp.

changes fan performance at a given speed and temperature and not the fan, one type fan is as "stable" as any.

Actually the fan should not be selected at point *B* or at point *C*. It should be selected at or near the peak of the static efficiency curve, if rated on static pressure, which, in the case of a forward-curved fan, is near the static-pressure peak. However, in practice, considerable variation is allowable.

By similar reasoning, it is the intersection of the system curve and the fan static-pressure curve that causes the fan to remain operating at the peak of this pressure curve. Physically, it is impossible for it to "slide down the pressure-curve hill," yet a number of people believe it actually will do this. With approximately a 4-fold pressure increase, the fan will be forced to the bottom of the "dip," at which point the fan continues to operate successfully, except that efficiency decreases and erosion increases.

Fig. 3 illustrates forward-curved fans in parallel. The volume at point *B* is the volume of two fans working together, likewise the horsepower is the sum of the two fans.

It can be seen readily that the volume of one fan at *A*, plus the volume of the other fan at *B*, will not equal the double volume at *B* when two fans are working at *B*. If one fan did work at *A* and the other at *B*, boiler output would suffer considerably, in fact would be $\frac{100 + 13}{2} = 56.5\%$ full rating.

Both fans are exactly alike, are on the same system, at the same speed, have identical characteristics. Since the whole chart of a fan must hang together, one fan cannot work at 20% velocity pressure and the other at 1% velocity pressure, points *B'* and *A'*. Both will work at equal velocity pressure, hence both must operate at point *B*.

Also, since both fans are operating under identical conditions, they must operate at identical efficiency and take the same horsepower.

If one of two induced-draft fans in parallel and separately motored is shut down, the motor that is operating is badly overloaded if nothing else is done. Three things can be done, and which is chosen depends upon what the fan is to accomplish.

If exactly half volume is wanted, the fan can be operated at reduced speed, determined from Fig. 3. The system-resistance curve for one fan at $\frac{1}{4}$ original pressure caused by $\frac{1}{2}$ volume, intersects the fan-pressure curve at 169% volume. Since volume varies directly with speed, and 100/169 volume is wanted, the speed is reduced in that ratio, which is 0.59, a speed reduction of 41%. In this case the horsepower is $(0.59)^3$ times the horsepower at full speed, which from the curve is 183% hp. Therefore, the horsepower for half volume using one fan is $(0.59)^3 \times 183 = 37.5\%$ full-speed, 2-fan hp. Incidentally, if both fans are operated half speed, the per cent total horsepower would be 25%, for half volume.

In case of a constant-load boiler, half volume will not suffice. In this case, one fan can be shut down for repairs, or for any cause, and the other operated full speed—figuring at the same time the motor of that fan will carry 25% overload. Since the fan requires 183% horsepower, the motors should be provided with a reserve of 50%. If each fan normally required 330 hp., and 330 × 1.50, or 500-hp. motors were provided, either would carry one fan with the other shut down.

Instead of losing half of his air by shutting down one fan, the boiler operator would lose only 15% of his total 2-fan amount of air; thus could operate his boiler at 85% load with half of his fan equipment shut down. When both fans are operating, the motors are still at top efficiency, at near $\frac{3}{4}$ load.

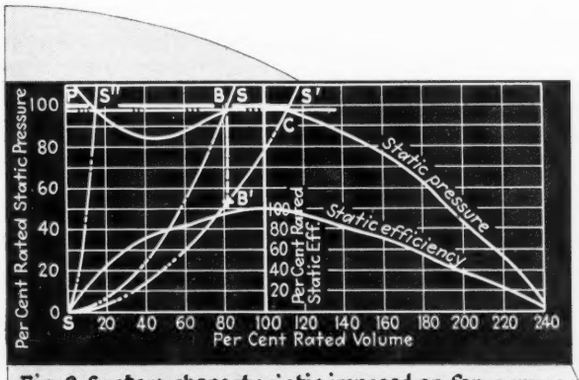


Fig. 2 System characteristic imposed on fan curves

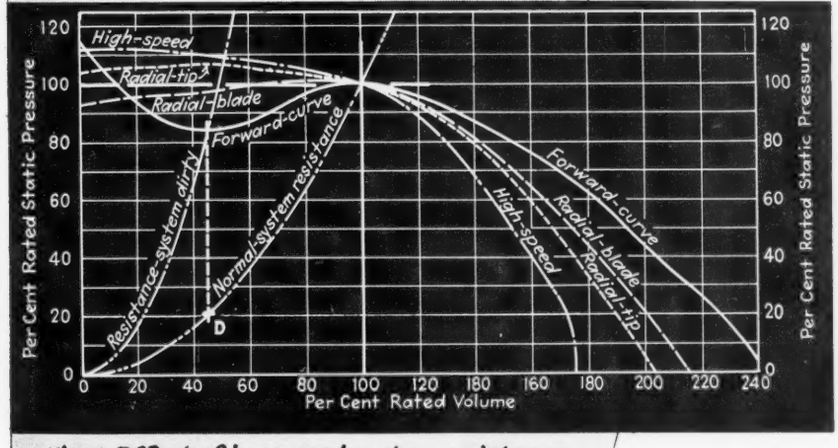


Fig. 4 Effect of increased system resistance on fan operation

This is a case of utilizing the steeper power characteristic of the forward-curved fan, at a first cost of a larger-frame motor.

A third thing is to operate one fan at full speed with the damper partially closed, and half volume will be obtained for half power.

Variable Load

When a boiler load can be reduced to allow one fan to operate at partial speed without dampering, or at full speed with partial dampering, no reserve motor power is necessary; most plants are so equipped, as most plants are variable-load plants.

With a high-speed, induced-draft fan there is no possibility of obtaining such excess air with one fan, because as it "lays down" in power, likewise it "lays down" in volume.

The radial-blade fan operates more nearly like the forward-curved fan for over-capacity, whereas the radial-tip fan more nearly approaches the high-speed.

All fans, except the forward-curved, have a pressure curve that more or less rises from full-open to full-closed position, or we will at least give them credit for this characteristic to give them maximum benefit of this discussion.

At the peak of the static efficiency, each has a different "reserve" pressure to overcome increasing system resistance. This is valuable when dampers are not used to throttle the fan for lower boiler ratings. The fan with the highest pressure "reserve" (the high-speed fan) dampers the least economically from a power standpoint.

Assume from Fig. 4, all fans shown are selected at the peak of the static-efficiency curve for best operation. Suppose the boiler, when dirty from ordinary causes, has a gas resistance loss of 100% pressure. But suppose some poor grade of coal causes the boiler to slag badly—its gas resistance increases beyond 100%.

The fan with the highest rising static will keep the boiler at the greatest rating, but the benefit from a rising static characteristic is less than one would assume at first glance. Actually what enables all fans to handle the volume they do is that, for decreased flow, system resistance goes down as the square of the drop in flow. Consider a system curve that intersects the forward-curve static-pressure line at the bottom of the valley, or at 45% rated volume. The per cent rated volume of the other three types as read from Fig. 4 is, radial tip 48%, radial blade 50%, and high-speed or backward-blade 51%. Normal system resistance for 45% volume is about 20% of the resistance for full volume, point *D*. Suppose the operator wants full boiler rating. No fan will give him this, unless he speeds it up considerably which requires excessive power. The practical point is to specify the maximum static pressure that no more will be needed, except in emergencies, and then there is nothing to do but remove the cause of the extreme excess friction.

If too much "emergency" static pressure is allowed during the original design then that fan selected will be too small, in outlet area, hence operate at poor efficiency, even though the speed is cut down to get the volume back to that specified. At a given r.p.m. this excess static pressure will cause too large a wheel diameter to be selected. If the fan system is throttled to build up the original specified pressure, excess horsepower will be involved. If the speed is cut down the smaller fan will operate at a higher ratio of capacity, have poorer efficiency and will scrub out more rapidly, because a fan at high ratio of capacity suffers from "sand blasting" of the abrasive material in the gas stream which will strike the back-plate or center plate of the wheel. All centrifugal fans have this characteristic.

Fig. 5 shows the four fan types selected as in Fig. 4 at peak of static efficiency, and shows the horsepower curves.

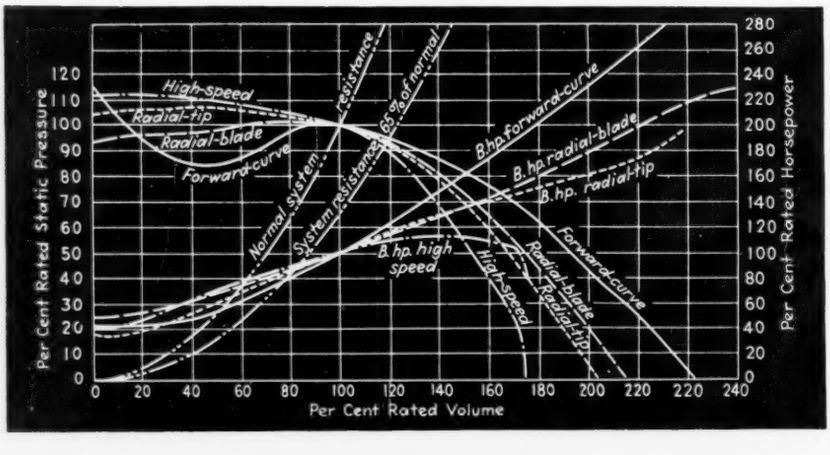
Pressure Drop vs. Horsepower

A 35% drop in pressure causes the horsepower to increase as follows: high-speed fan 8½%, radial-tip fan 15%, radial-blade fan 13%, forward-curved fan 23%. A motor selected with no factor of safety at all will not be damaged in each case. A motor selected with 10% factor above fan b.hp. will be 20% overloaded with a forward-curved fan when system resistance drops 50%.

The forward-curved fan takes the most power, but is delivering the most air. Hence the forward-curved fan will cause the boiler to put out the most steam when the system resistance is dropped. The other two types fall between these limits.

These curves are plotted on the basis of all fans at the peak of the static-efficiency curve. Each fan is compared to the rest where they are operating at minimum cost. These relative values can be "juggled" some either way to increase or decrease the relative advantage of each type, by not comparing them all at this same point of maximum static efficiency, but there is little use in attempting this.

Fig. 5—Effect of drop in system resistance on fan horsepower



Correction

IN THE article, "Drying Methyl Chloride" on page 579 of the November, 1935, number of *Power*, calcium oxide was mentioned as a drying agent and methyl alcohol as an antifreeze. The application of these chemicals to methyl-chloride refrigeration systems is claimed in patents which are not held by The duPont Company and they should be considered in any proposal to utilize one of these methods.

TO AVOID LIABILITY

By Leo T. Parker
Attorney at Law, Cincinnati

FREQUENTLY, employers may avoid liability on suits for damages filed by injured employees and other persons, or payment of compensation under State Compensation Laws, particularly if the injury resulted while the employee was acting outside the scope of the employment, or as a result of his own negligence.

Generally speaking, statements or acts of employees or others immediately after an accident may greatly influence the chances of a plant owner or other employer being held liable in damages for the injury. Moreover, power and mechanical engineers may perform certain acts and make certain records which will assist the employer in winning the suit.

It is well known that any person, such as an engineer, who is especially capable in supervision of power-service equipment, is qualified to give expert testimony. Also, it is important to know that the distinction between an ordinary witness and an expert witness is that the former is not permitted to testify as to conclusions, whereas the latter may do so. This is true because conclusions are the essence of the jury's decisions and only the jury may interpret and construe the testimony of an ordinary witness for the purpose of arriving at a final verdict.

Therefore, in a legal controversy involving an injury to an employee, an ordinary witness may testify regarding the defect or thing which caused the injury, and he may express his opinion with respect to the quality or kind of defects, but he is not permitted to conclude that the defects or the poor workmanship actually resulted in the injury. However, an engineer may testify as to whether he believes the defect to be dangerous.

Most people believe that a good witness is one capable of giving testimony in favor of one or the other of the litigants. However, all Courts have consistently stated that the best witness is a person who gives truthful testimony and who cannot be confused during cross-examination, nor induced by cross-examining lawyers to give answers which may lead the jury to believe anything other than the exact truth.

What to Do

Now, therefore, since suits cannot be won except by the introduction of favorable testimony likely to convey intelligence to the jury, every engineer should make an effort to: (1) Inquire of the injured person or employee immediately after the accident, as to what caused the injury. (2) Inquire as to what the injured employee was doing immediately before occurrence of the accident. (3) Inquire whether the injured person knew that the object or defect which caused the injury had been existing. (4) Learn whether the injured person had previously suffered a similar injury, and if so, when and where. (5) Request the injured person to describe exactly what he was doing just before the injury and in detail how the injury was sustained. (6) If possible, take the names and addresses of at least three persons who witnessed the injury and, also, know that certain witnesses heard the injured person's answers to the above-mentioned questions asked by the engineer. (7) Make notes at the time of the questioning, or immediately afterward, so that these notes may be referred to at any future time, as when on a witness stand, to obtain correct answers to questions. This is permitted and refreshes the mind of the engineer. (8) If possible, have the injured person sign a statement covering questions 1 to 5.

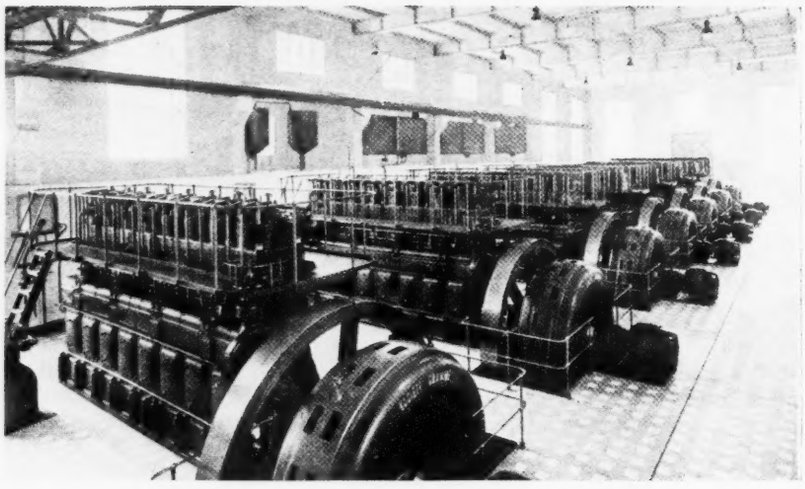
The important thing to remember is that an injured employee or other person is not entitled to recover damages for an injury: (1) if his negligence or carelessness resulted in the injury; (2) or, if he had seen or known of a defect in a tool, equipment, floor, stairway, poorly illuminated location, or the like, which caused the injury; (3) or, if the defect which caused the injury was made by another employee without knowledge of the owner of the plant; or, if the premises had been recently inspected and the defect or object which caused the injury was not discovered when the inspection was made.

Known Hazard

Another important point of the law is that an employer is not an insurer of the safety of patrons and others who are lawfully in the building. Also, in order to impose liability for injuries to an employee by reason of a dangerous or defective condition, the injured person is bound to prove that the condition which caused the injury was known to the employer, or his agent, the engineer, and that it existed for such time that it was the legal duty of the employer or his engineer to discover it and make the necessary repairs.

In other words, the outcome of all suits against plant owners for injuries to employees and other persons depends on whether the engineer, or other authorized employee, had knowledge or should have had knowledge of the danger or defect which caused the injury and, also, whether by the application of an ordinary degree of care he should have discovered and remedied it.

In all cases involving injury to employees, the most important evidence to be introduced by the plant or building owner is that the thing causing the injury had been recently inspected and that no defects were discovered. A patron may prove by convincing testimony that a defect existed when the injury was sustained, but the plant owner may counteract this testimony and, in many instances, avoid liability by proving that no defect was *apparent* during a *recent* inspection of the premises. An employer is not expected by the Courts to discover and remedy hidden defects.



Seven diesel sets deliver 60,000 kw.-hr. per day at Clairvivre

THE DIESEL AND ITS FUEL

*By Harry R. Ricardo, F.R.S.**

IN HIGH-SPEED diesels the engine is much less sensitive to its fuel than in spark-ignited gasoline engines. In gasoline engines, not only the specific power output but even the whole general design, depends almost entirely on the octane number of the fuel, so much so in fact that an engine designed to make best use of 100-octane gasoline will develop double the power output of one designed for 70-octane. No comparable relation exists or ever is likely to exist between the fuel and engine performance in diesel engines.

In gasoline engines, we are working normally with a relatively low ratio of compression, therefore on the steep part of the air-cycle efficiency curve. Any increase in octane number permits us to work further up the efficiency curve and allows us also to increase the amount of supercharge. In a diesel engine, the ratio of compression is already set, so that we are working on a nearly flat portion of the curve and efficiency is virtually unaltered over a wide range, while supercharging is unlimited by the incident of detonation. We can supercharge as much as we like, and to an equal extent, with any fuel. The limit is determined solely by maximum cylinder pressure we are prepared to tolerate. In other words, if it will run at all, a compression-ignition engine will give substantially the same power output and efficiency on any fuel which it can burn. The nature of the fuel is likely to have influence only on such secondary factors as silence, ease of starting, etc.

In the diesel, ignition takes place from the surface of a vast number of liquid droplets all traveling in definite directions, and the problem is to bring air to these droplets at at least as great a rate as it is being consumed by the burning fuel. This requires an orderly movement of the air across the fuel stream. Mere turbulence, as in the gasoline engine, is of little help, since as much as possible of the air within the cylinder must pass across the stream of burning droplets. This can be obtained best by setting the air within the combustion chamber into a unidirectional flow more or less at right angles to fuel flow.

The combustion process may be divided into three stages: first, a delay period during which the surface of each individual droplet is surrounding itself with an envelope of vapor, the outer surface of which must retain such a temperature as to bring about self-ignition; second, a phase of very rapid burning while the many droplets which have accumulated during the delay period, and which are surrounded by fresh and uncontaminated air, all burst into flame in rapid succession; third, a phase of controlled burning when, owing to very high temperatures within the cylinder, the last droplets burst into flame almost as they enter the combustion chamber.

During the third phase we have almost complete control over rate of burning, and therefore pressure, since these depend almost solely on the way in which we choose to admit fuel. I say "almost complete control" because in spite of all the intensive study which has been devoted to the design of injection equipment we have not yet seen complete mechanical control of the rate of admission. From the point of view of pressure control and smoothness of running, generally we want to speed up the first two phases and carry out as much of the combustion process as we can under the conditions of Phase 3. In many earlier high-speed diesel engines, Phases 1 and 2 occupied so large a proportion of the whole process that Phase 3 was elbowed almost entirely out of existence.

Evils of prolonging the delay period are fairly obvious, for in the first place the more unburned fuel that accumulates during this phase the more violent will be the rate of pressure rise during Phase 2, and the greater the diesel knock. Furthermore, if the fuel be a fairly volatile one, with a relatively high self-ignition temperature, there is the danger of small pockets of vaporized combustible mixture being formed, and of their being detonated just as in a gasoline engine. If the delay period, therefore, is unduly prolonged, not only shall we have no proper control over the rate of pressure rise, which may be such as to cause a heavy knock, but with certain fuels and under certain conditions, we shall get superimposed on this heavy diesel knock a high-pitch "ping," such as we are accustomed to hear in a gasoline engine when detonating.

We can speed up the delay period thus:

1. By raising the ratio of compression.
2. By adding heat to the air during compression.
3. By reducing the size and increasing the dispersion of the fuel droplets.
4. By using a fuel of high cetene value or low self-ignition temperature.

With regard to the first, we are limited as to compression ratio which we can usefully employ, for whatever the type or form of the combustion chamber, there must inevitably be some air left outside in the cavity provided for the valves or in the clearance space between piston and cylinder, necessitated by purely mechanical conditions. This air is in thin and inaccessible layers, which cannot be reached by the fuel, nor even if it were reached, would it be hot enough for rapid combustion. In any given size of engine the quantity of outlying air is constant, and as the ratio of compression is raised, the capacity of the effectvie combustion chamber is reduced. Thus the proportion of outlying air increases. Hence maximum power output, which is purely a function of the amount of air we can burn, diminishes as compression ratio is raised. A small proportion of outlying air is always desirable, for it serves to consume completely any half-suffocated droplets which have entered the combustion chamber after most of the oxygen has already been consumed by earlier arrivals, but this process occurs too late in the cycle; in time to clean up the exhaust, but not in time to give any useful addition to the power output. It follows, therefore, that if we raise ratio compression beyond a certain point and still work to a given maximum pressure, we gain nothing in thermal efficiency and lose appreciably in power output.

Fixed Injection Timing

By fitting heat-insulated members in the combustion chamber which act as regenerators, we can add heat to the air during compression, but here again we are limited to a certain extent in that all the heat received and stored by such insulated members is taken from that of combustion—on full load we have plenty and to spare, but on light loads or when running idle we are hard put to it to find enough. By such means we can

*An abstract of a paper, "The Progress of the Internal Combustion Engine and its Fuel," before the Institute of Fuel and other societies, London, England, recently. Mr. Ricardo is the latest Melchett Medallist of the Institute.

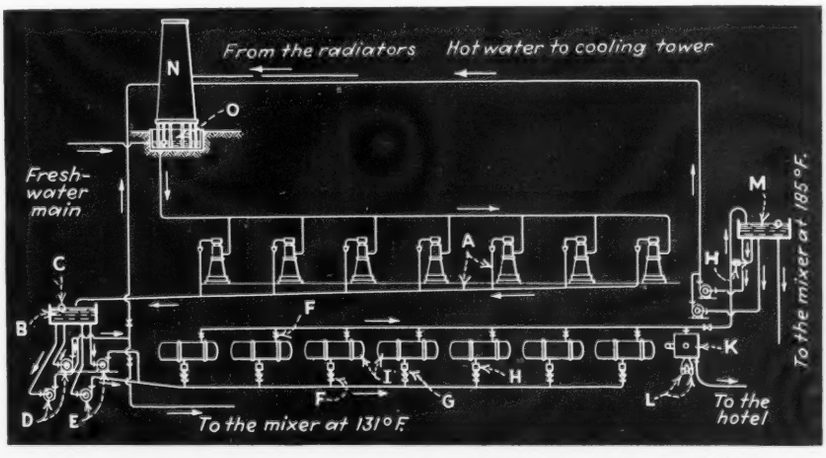
make the delay period almost as short as we like on full load, but under prolonged running and on light loads it is liable to lengthen out again. None the less, this is the practical way of curtailing delay, all the more so since the temperature of the heat-insulated members tends to rise rapidly with increase of speed. It can thus be made auotmatically to keep the proportional delay constant, and therefore allow of fixed injection timing over the whole range of speed.

By reducing the size and increasing droplet dispersion, we can reduce the delay. But in practice we are very limited in this direction, for reduction of size involves reduction of penetration, and in most types of combustion chambers we need nearly all the penetration we can get, more especially if we are using a high compression ratio. By employing a high cetene number of fuel, that is to say, a fuel whose self-ignition temperature is relatively low, we can, of course, reduce delay by increasing the differential betwen the air temperature and fuel self-ignition temperature.

We want to reduce the delay period as much as possible, but, like everything else, we can overdo it. If there were no delay period at all the fuel would burn immediately as it entered from the injector and the whole process of combustion would be concentrated around the nozzle of the injector. Then what chance would the rest of the air have of finding fuel? We should get beautiful smooth running with perfect control, but very little power. We need, in fact, a delay period of sufficient duration to allow fuel to penetrate into the chamber before combustion starts.

In most systems, a moderately high, but not too high, cetane value is advantageous, in that it serves to shorten the delay period and thus allow better control over rate of burning and pressure rise. As in the case of gasoline, the cetene value of various fuels depends mainly on the source of origin, but can be varied somewhat by varying the distillation range or by doping with such substances as amyl nitrite, ethyl nitrate or certain peroxides. Generally speaking, any source which yields a low-octane gasoline will yield a high-cetene diesel oil, and vice versa. As to volatility in general, within limits, the lower the volatility the better, since too volatile a fuel is liable both to cause detonation and to give rise to gassing troubles in the fuel injection system. At the other end of the scale, if the volatility is too low, a further delay period will be introduced, due to the greater time taken to form a gas envelope on the outside surface of the droplets, as has been pointed out by Boerlage and Broeze. We are still a long way off any cut-and-dried specification for diesel fuels, for the reason that the different types of high-speed diesel engines have such widely differing tastes—some requiring strict dieting, others can enjoy the whole of the menu.

DIESELS HEAT A TOWN



Heat Recovery at Clairvivre

A hot water from diesels, B hot-water tank at 185 deg. F., C float control for starting pumps D, D 2 pumps each delivering 425,000 g.p.h., E 2 pumps each delivering 12,950 g.p.h., F stop valve, G thermostat-controlled equalizing valve, H non-return valve, I waste-heat boilers, K oil-fired boiler, L fans, M 134,300 gal. tank, N 554,000-g.p.h. cooling tower, O 134,300-gal. cooled-water tank

THIRTY miles from Périgueux and Brive, France, the Fédération Nationale des Blessés du Poumon et des Chirurgicaux (Ass'n for Treatment of Tuberculosis) has built Clairvivre Village, a garden city of 180 houses, each with two apartments, a 200-person hotel, administrative buildings, hospital, general stores and factories. The plan is to make the village self-sustaining, so it has its own water-pumping and electric plants, the latter with seven 635-kw. Sulzer diesel sets with peak output of 4,900 kw.

All the large buildings are heated by hot waste water from the diesel station, and individual houses are heated by electricity, the houses taking 1,500 kw. on coldest days, total winter electrical load running to 60,000 kw.-hr. per day (36,000 for heating, 24,000 for services and light). The seven engines in the station make it possible to operate at highest efficiency for a given load, thus fuel requirements are only 0.51 lb. per kw.-hr. or 30,400 lb. per day in winter. Engine efficiency is 34%.

Of the 66% of the heat value of the fuel in cooling water and waste gases, cooling water takes 2,700 B.t.u. per hp.hr. at full load (800 b.hp.), a total of 2,160,000 B.t.u. Each diesel is supplied 5,375 gal. of cooling water per hr., which is raised 48.5 deg. F. (82.5 to 131). Total water per day, 537,500 gal., flows into a 12,080-gal. tank, then to seven fire-tube waste-heat boilers utilizing 800,000 B.t.u. per hr. at full load on the diesels to heat the water to 185 deg. F. Two electrically driven pumps (one standby) deliver 13,430 gal. of the 131-deg. water per hr. against 60-ft. head to the boilers, then to a 134,300-gal. storage tank. With the 60,000-kw.-hr. per day load on the plant, 188,000 gal. of water can be thus heated. An oil-fired boiler provides 1,400,000 B.t.u. per hr. in case power demand is out of phase.

Three of the large buildings are arranged for central heating and hot-water supply, with 86-deg. F. temperature drop, thus requiring 14,770 gal. of water per hr., obtained by mixing 185-deg. water with 131-deg. water to get 158-deg. inlet and 104-deg. outlet temperatures. At minimum outside temperatures, this installation uses 159,000,000 B.t.u. per day, or 29% of the heat value of the fuel. This gives diesel plant efficiency of $34 + 29 = 63\%$, equivalent to the mean efficiency of an ordinary industrial oil-fired boiler. This high efficiency permits use of the electrical energy for heating the small houses, avoiding ashes, coal- and ash-handling and attendant difficulties, or the extensive piping and large heat losses of a central system. Two 14,530-g.p.h. (one standby) pumps deliver heating water in winter, and two 3,960-g.p.h. (one standby) in summer. Longest circuit is 1,200 ft., flow rate runs 200 to 400 f.p.m., pressure is 24 lb. per sq.in. Because of this, pipe can be small and heat losses are thus reduced. Piping leaving the station is $4\frac{3}{4}$ to 5 in. in diameter, and is intended to transmit 6,350,000 B.t.u. per hr. Total piping is 19,500 ft., 9,000 ft. of it 0.4 to 0.7 in. in diameter. This piping is in ducts, with cork and cement insulation.

Returns from the heating system (376,000 gal. per day at 104 deg. F.) and overflow from the 12,080-gal. (161,000 gal. per day at 131 deg. F.) are taken into a spray-type cooler and lowered from 113 to 82.5 deg. F., thus taking away 131,000,000 B.t.u. per day, or 24% of the total heat in the fuel. The remaining 13% of heat is that lost in exhaust gas, which leaves the waste-heat boilers at 302 deg. F., and that radiated by the engines.

Hot water for the hotel is produced in six 350-gal. per hr. heaters, that for the hotel in two 350-gal. heaters, and for the stores in a 110-gal. heater, all using the 158-deg. water. The stores are heated by hot air from the vertical shafts carrying hot-water piping.

Drinking water is obtained in a rather interesting way. Granite strata and a dry season make wells impractical, except from sources too far away, and a local pond would have to be dug out and dammed at high cost. Instead, water is obtained from a concrete-lined filter gallery in alluvial soil along an important stream (l'Auvezere) 5 miles away. A diesel-driven 80-g.p.m. pump, pumping against 642-ft. head raises the water. A duplicate set is available for standby, plus a low-lift, high-output pumping set (2,640 g.p.m.) for low-water periods. This set takes water from a settling tank on the river upstream and pumps it into a trench parallel to the filter gallery and 15 yards away. There is also a third source of water for emergency, two reservoirs of another municipality.

SPEAKING OF POWER

● On the evening of January 21, 1936—just two hundred years and two days after Watt's birth in Greenock, Scotland—his ghost donned its faded tail coat and looked in on the Franklin Institute dinner in Philadelphia. . . . This shade of an instrument maker, son of a "jack of all trades," was not particularly surprised to learn that his engines had been a success. With the aid of hard-headed Matthew Boulton, he had seen worthwhile business results in his own lifetime.

But Watt was surprised to discover that Trevithick wasn't a fool in proposing 40 lb. steam pressure. . . . He was particularly amazed to find that he was directly responsible for the Industrial Revolution and indirectly for mass production, automobiles, airplanes, jazz, the radio, the electric light, subways, the *Normandie,* the World War, the New Deal and some of the latest dance steps. . . . Of course, such things would not be said in so many words at a dignified Franklin Institute function, but it is the inevitable conclusion of every evaluation of Watt's influence.

...amazed at 40

The moral is this: The man who changes life at its energy roots starts a train of events too vast for any imagination to predict. Watt worked well. He did the fundamental things. He set the wheels in motion. He created an infinite power for good and evil. It will take only common sense and ordinary human decency to make it a power of infinite good.

...steam by wire

I have been one of those who saw no use for an electric boiler except to get some good out of waste hydro power. Certainly 300 kw.-hr. is a lot to pay for 1,000 lb. of steam. At 1 cent per kilowatt the steam would cost $3.00 per thousand. Nothing doing! . . . But the article on St. Croix Paper (page 79) gives me an idea. St. Croix produces 200,000 kw.-hr. extra by steam turbines during the week and uses it to store water above the dam. Then they shut down their coal boilers over the week-end, heat the plant with a hydro-served electric boiler and save 70 tons of coal. This is possible because the 200,000 kw.-hr. are byproduct power (costing only 30 tons of coal) and because the coal-fired boiler is very inefficient on week-end loads. . . . Here is another fine example of what happens when brains are applied to an operating job.

It is a real pleasure to see some of my consulting-engineer friends busy again after a none-too-pleasant 5-year siesta. The particularly comforting thought is that the competent power consultant generally hands his client dollar benefits that make his fee look like the proverbial drop in the bucket. Manufacturers have done a splendid job in giving engineering advice as a premium to customers, but there is, and always will be, a major place for the disinterested expert who has nothing to sell but his own brains and experience.

Frank Betts, from his hangout in the Milwaukee Courthouse, chides the editor for this bit of arithmetic: $81 \times 0.7854 = 62.174$ [instead of 63.6174]. This appeared on page 647 of the December number, under the heading "Easier than Pie." "Shall we say the drinks are on the house?" asks Mr. Betts, and we say they are. . . . However, we are inclined to defend the next multiplication criticized: $81 \times 0.78 = 64$. This time the factor 0.7854 was shortened for a quick estimate of the area of a piston—the sort of rough figuring you do in your head while walking around a plant. If the 81 is obtained by squaring the guess of the diameter and 0.78 is used instead of 0.79 because it is easier, if not so close, it is hardly inconsistent to round out the mental product to an even 64. . . . We know scores of highly trained engineers who make estimates that way. They have an answer close enough for many practical purposes while the other fellow is still looking for his pencil. They know when to figure to five places and when an answer within 1%, or even 10%, is plenty close enough. . . . 10%, for example, is often close enough in estimating the weight of a casting to be moved or lifted.

...on us

...on my way

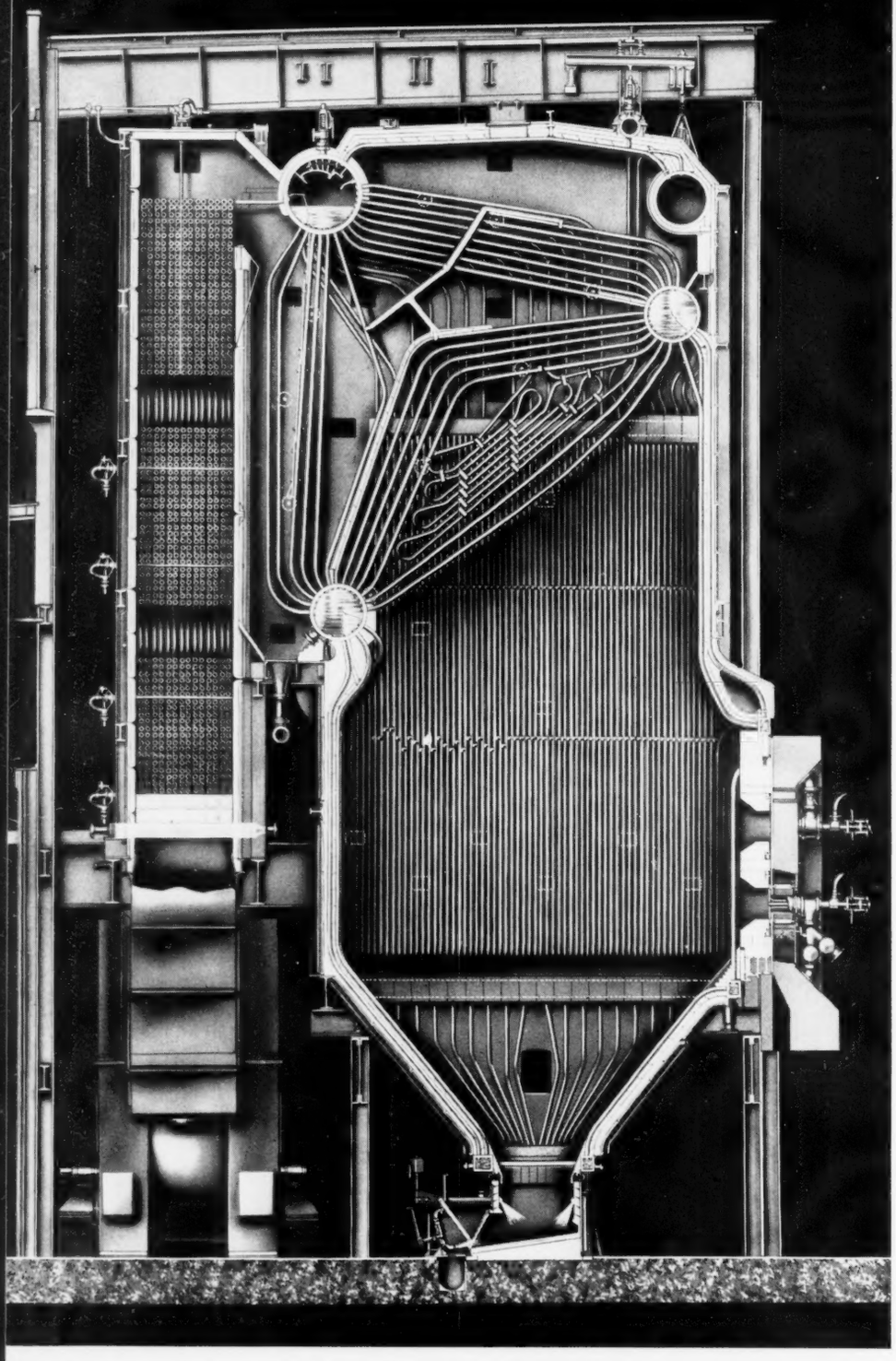
Last month I hinted at extensive travels to come. Now I can announce a European editorial tour through Germany, Switzerland, France and England. I sail Feb. 20. The immediate object of this trip is to cover the Leipzig Fair, March 1-9. This is the world's largest business and industrial show and will include about 2,000 engineering exhibits. . . . The Germans, as you know, have done quite a bit with diesel engines, boilers, pumps, etc., and I expect to find a lot of interesting things along these lines. After Leipzig I shall spend another week in Berlin and other German cities, visiting engineers, factories and power plants. . . . This will be followed by shorter stays in Switzerland, France and England and I should sight the U.S.A. again about the first of April. . . . The editorial problem, as usual, will not be to report everything I bump into, but to look at plants and machines with an American eye to see what things they do better than we do—what ideas and methods we might adopt here to our own profit.

PHIL SWAIN
Editor

JAMES WATT

He didn't invent the steam engine—he took a crude mine-pumping "fire engine", and, with the support of Matthew Boulton, made of it the prime mover which brought on the Industrial Revolution. He invented the double-acting engine, throttle valve, indicator, mercury steam gage, flyball governor, separate condenser, stuffing box and steam jacket. He was born 200 years ago Jan. 19.

This statue of Watt stands before Packard Laboratory at Lehigh University, which sponsored the Watt Bicentennial last month. Photo by W. Mansfield White



A Typical Modern Riley Unit

300,000 lbs. of Steam per hour— 646 lbs. Pressure—740°F. Steam

For

The following Companies recently installed Riley Steam Generating Units to obtain Lowest Steam Costs.

Lynn Gas & Electric Co., Lynn, Mass.
Holyoke Water Power Co., Holyoke, Mass.
Socony-Vacuum Oil Co., Naples, Italy
Standard Oil Co. of California, Richmond, Calif.
Upper Michigan Power & Light Co., Escanaba, Mich.
Collins & Aikman Corporation, Philadelphia, Pa.
Celanese Corporation, Cumberland, Md.
Whippany Paperboard Co., Whippany, N. J.
Owens-Illinois Glass Co., Newark, Ohio
American Laundry Machine Co., Rochester, N. Y.
Carbide & Carbon Chemicals Corp., S. Charleston, W. Va.
Crystal Tissue Paper Co., Middletown, N. Y.
Arnold Print Works, N. Adams, Mass.
Savannah Sugar Co., Savannah, Ga.
E. Hubschman & Sons. Philadelphia, Pa.
Government of Virgin Islands, Christiansted, V.I.
Beechnut Packing Co., Canajoharie, N. Y.
Crompton & Knowles Loom Works, Worcester, Mass.
Titanium Pigment Co., Sayreville, N. J.
W. Va. Pulp & Paper Co., Covington, Va.
W. Va. Pulp & Paper Co., Luke, Md.
Ames Worsted Co., Southbridge, Mass.
Charlton Woolen Co., Charlton, Mass.
Kalamazoo Vegetable Parchment Co., Kalamazoo, Mich.
American Oak Leather Co., Louisville, Ky.
Forstmann Woolen Co., Garfield, N. J.
Forstmann Woolen Co., Passaic, N. J.
Finch Pruyn Co., Glens Falls, N. Y.
North Carolina State Hospital, Goldsboro, N. C.
Central Juanita, Bayamon, Puerto Rico.
Shell Corporation, Woodriver, Ill.
Public Service Electric & Gas Co., Paterson, N. J.
Norton Company, Worcester, Mass.
Tsishuyen Electric Works, China
German Brewery, Cumberland, Md.

THE SWING continues to RILEY

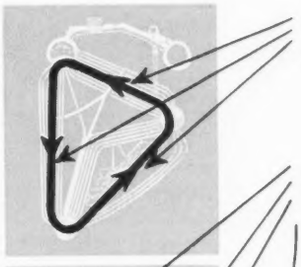
1935 WAS A RILEY YEAR

Sales of Riley Steam Generating Units in 1935 were 32% greater than in 1929—the previous best year

Lowest Steam Costs the RILEY BOILER

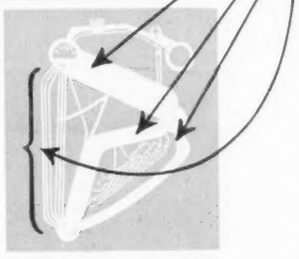
THESE DISTINCTIVE CHARACTERISTICS OF RILEY BOILERS ASSURE FULFILLMENT OF THE PROMISE OF LOWEST STEAM COSTS . . .

Minimum Resistance to Circulation



The large areas provided through boiler tube banks reduce resistance to circulation to a minumum.

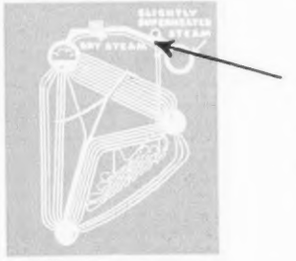
Maximum Force Producing Circulation



All tubes exposed to high temperatures carry upward flow of water and steam bubbles. This directional effect, together with the large head producing flow, insures rapid, positive circulation in a fixed direction in all of the tubes, with a very definitely increasing rate of circulation as the steam output increases.

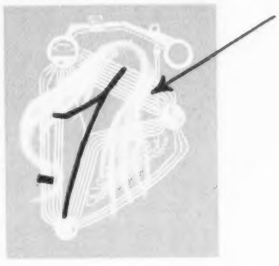
The rapid circulation resulting from the above design characteristics immediately removes all steam bubbles as formed, insuring proper intimate contact between water and tubes which, together with gas baffling for the most effective heat transfer, results in low flue gas temperatures.

Dry, Slightly Superheated Steam



Overcomer tubes connecting the third and fourth drums entirely remove the slight residual moisture from the steam and deliver it dry and superheated 10 to 20 degrees F. to the fourth drum.

Cross Flow of Gases over Heating Surfaces



Riley Boilers are baffled so as to obtain cross flow of gases over the heating surfaces with most effective heat transfer resulting. Baffling is so arranged and gas passages so proportioned as to result in unusually low draft losses. Careful consideration is also given to provision for easy access for inspection.

In addition to the above, and other distinctive features of design, you are assured, when purchasing Riley Steam Generating Equipment, of the highest quality materials and workmanship both in manufacture and erection. Unusual satisfaction, high efficiency continuity of operation, and low maintenance result from these plus values. A visit to some of the recent installations of Riley Steam Generating Units will make these plus values perfectly apparent to you. One-eighth-inch scale drawings of recent Riley installations will be gladly sent you upon request.

RILEY STOKER CORPORATION

WORCESTER, MASS.

BOSTON NEW YORK PHILADELPHIA PITTSBURGH BUFFALO CLEVELAND DETROIT TACOMA ST. LOUIS
CINCINNATI CHICAGO ST. PAUL KANSAS CITY LOS ANGELES INDIANAPOLIS ATLANTA HOUSTON

COMPLETE STEAM GENERATING UNITS

BOILERS - PULVERIZERS - BURNERS - STOKERS - SUPERHEATERS - AIR HEATERS
ECONOMIZERS - WATER-COOLED FURNACES - STEEL-CLAD SETTINGS

© POWER

Belt Speed in F.P.M. for Given Pulley Diameter and R.P.M.

Speed, R.P.M.	100	110	120	130	140	150	160	170	180	190	200	210	220	230	250	275	300	325	350	375	400	450	500	600	700	750	900	1,200	1,500	1,800
Pulley Diam., Inches	**Belt Speed in Feet Per Minute**																													
2	52	58	63	68	73	79	84	89	94	100	105	110	115	120	130	145	155	170	185	195	210	235	260	315	365	395	470	630	785	940
2½	65	72	78	85	92	98	105	110	120	125	130	135	145	150	165	180	195	210	230	245	260	295	325	395	460	490	590	785	980	1,180
3	78	86	94	100	110	120	125	135	140	150	155	165	175	180	195	215	235	255	275	295	315	355	390	470	550	590	710	940	1,180	1,410
3½	92	100	110	120	130	135	145	155	165	175	185	190	200	210	230	250	275	300	320	345	365	410	460	550	640	685	825	1,100	1,380	1,650
4	105	115	125	135	145	155	170	180	190	200	210	220	230	240	260	290	315	340	365	395	420	470	525	630	735	785	940	1,260	1,570	1,880
4½	118	130	140	155	165	175	190	200	210	225	235	250	260	270	295	325	355	385	410	440	470	530	590	705	825	885	1,060	1,410	1,770	2,120
5	131	145	155	170	185	195	210	225	235	250	260	275	290	300	325	360	395	425	460	490	525	590	655	785	915	980	1,180	1,570	1,960	2,360
5½	144	160	175	185	200	215	230	245	260	275	290	305	315	330	360	395	430	470	505	540	575	650	720	865	1,010	1,080	1,300	1,730	2,160	2,590
6	157	175	190	205	220	235	250	265	285	300	315	330	345	360	395	430	470	510	550	590	630	705	785	940	1,100	1,180	1,410	1,880	2,360	2,830
7	183	200	220	240	255	275	295	310	330	350	365	385	405	420	460	505	550	595	640	685	735	825	915	1,100	1,280	1,370	1,650	2,200	2,750	3,300
8	210	230	250	270	295	315	335	360	375	400	420	440	460	480	525	575	630	680	735	785	840	940	1,050	1,260	1,470	1,570	1,880	2,510	3,140	3,770
9	235	260	285	305	330	355	375	400	425	450	470	495	520	540	590	650	705	765	825	885	940	1,060	1,180	1,410	1,650	1,770	2,120	2,830	3,530	4,240
10	260	290	315	340	365	395	420	445	470	495	525	550	575	600	655	720	785	850	915	980	1,050	1,180	1,310	1,570	1,830	1,960	2,360	3,140	3,930	4,710
11	290	320	345	375	405	430	460	490	520	545	575	605	635	660	720	790	865	935	1,010	1,080	1,150	1,300	1,440	1,730	2,020	2,160	2,590	3,460	4,320	5,180
12	315	345	375	410	440	470	505	535	565	595	630	660	690	725	785	865	940	1,020	1,100	1,180	1,260	1,410	1,570	1,880	2,200	2,360	2,830	3,770	4,710	5,660
13	340	375	410	440	475	510	545	580	615	645	680	715	750	785	850	935	1,020	1,110	1,190	1,280	1,360	1,530	1,700	2,040	2,380	2,550	3,060	4,080	5,100	6,130
14	370	405	440	475	515	550	585	625	660	695	735	770	805	845	915	1,010	1,100	1,190	1,280	1,370	1,470	1,650	1,830	2,200	2,570	2,750	3,300	4,400	5,500	
15	390	430	470	510	550	590	625	670	705	745	785	825	865	905	980	1,080	1,180	1,280	1,370	1,470	1,570	1,770	1,960	2,360	2,750	2,940	3,530	4,710	5,890	
16	420	460	505	545	585	630	670	710	755	795	840	880	920	965	1,050	1,150	1,260	1,360	1,470	1,570	1,680	1,880	2,090	2,510	2,930	3,140	3,770	5,030	6,280	
17	445	490	535	580	625	670	710	755	800	845	890	935	980	1,020	1,110	1,220	1,340	1,450	1,560	1,670	1,780	2,000	2,220	2,670	3,120	3,340	4,010	5,340		
18	470	520	565	615	660	705	755	800	850	895	940	990	1,040	1,080	1,180	1,300	1,410	1,530	1,650	1,770	1,880	2,120	2,360	2,830	3,300	3,530	4,240	5,660		
19	500	545	600	650	695	745	795	845	895	945	995	1,040	1,090	1,140	1,240	1,370	1,490	1,620	1,740	1,870	1,990	2,240	2,490	2,980	3,480	3,730	4,480	5,970		
20	525	575	630	680	735	785	840	890	940	995	1,050	1,100	1,150	1,200	1,310	1,440	1,570	1,700	1,830	1,960	2,090	2,360	2,620	3,140	3,660	3,930	4,710	6,280		
21	550	605	660	715	770	825	880	935	990	1,040	1,100	1,160	1,210	1,260	1,370	1,510	1,650	1,790	1,920	2,060	2,200	2,470	2,750	3,300	3,850	4,120	4,950			
22	575	635	690	750	805	865	925	980	1,040	1,090	1,150	1,210	1,270	1,320	1,440	1,580	1,730	1,870	2,020	2,160	2,300	2,590	2,880	3,460	4,030	4,320	5,180			
23	600	660	725	785	845	905	965	1,020	1,080	1,140	1,200	1,260	1,320	1,380	1,500	1,660	1,810	1,960	2,110	2,260	2,410	2,710	3,010	3,610	4,220	4,520	5,420			
24	630	690	755	820	880	940	1,000	1,070	1,130	1,190	1,260	1,320	1,380	1,440	1,570	1,730	1,880	2,040	2,200	2,360	2,510	2,830	3,140	3,770	4,400	4,710	5,650			
26	680	750	815	885	955	1,020	1,090	1,160	1,220	1,290	1,360	1,430	1,500	1,570	1,700	1,870	2,040	2,210	2,380	2,550	2,720	3,060	3,400	4,080	4,760	5,100	5,890			
28	735	805	880	955	1,030	1,100	1,170	1,250	1,320	1,390	1,470	1,540	1,610	1,690	1,830	2,020	2,200	2,380	2,570	2,750	2,930	3,300	3,660	4,400	5,130	5,400	6,130			
30	785	865	940	1,020	1,100	1,180	1,260	1,340	1,410	1,490	1,570	1,650	1,730	1,810	1,960	2,160	2,360	2,550	2,750	2,940	3,140	3,530	3,930	4,710	5,500	5,890				
32	840	925	1,000	1,090	1,170	1,260	1,340	1,420	1,510	1,590	1,680	1,760	1,840	1,930	2,090	2,300	2,510	2,720	2,930	3,140	3,355	3,770	4,190	5,030	5,860	6,280				
34	890	980	1,070	1,160	1,250	1,340	1,420	1,510	1,600	1,690	1,780	1,870	1,960	2,050	2,220	2,450	2,670	2,890	3,120	3,340	3,560	4,010	4,450	5,340	6,230					
36	940	1,040	1,130	1,220	1,320	1,410	1,510	1,600	1,700	1,790	1,880	1,980	2,130	2,170	2,360	2,590	2,830	3,060	3,300	3,530	3,770	4,240	4,710	5,660						
38	995	1,090	1,190	1,290	1,390	1,490	1,590	1,690	1,790	1,890	1,990	2,090	2,250	2,290	2,490	2,740	2,980	3,230	3,480	3,730	3,980	4,480	4,970	5,970						
40	1,045	1,150	1,260	1,360	1,470	1,570	1,680	1,780	1,880	1,990	2,090	2,200	2,360	2,410	2,620	2,880	3,140	3,400	3,660	3,930	4,190	4,710	5,240							
42	1,100	1,210	1,320	1,430	1,540	1,650	1,760	1,870	1,980	2,090	2,200	2,310	2,480	2,530	2,750	3,020	3,300	3,570	3,850	4,120	4,400	4,950	5,500							
44	1,150	1,270	1,380	1,500	1,610	1,730	1,840	1,960	2,070	2,190	2,300	2,420	2,590	2,650	2,880	3,170	3,460	3,740	4,030	4,320	4,610	5,180	5,760							
46	1,200	1,320	1,440	1,570	1,690	1,810	1,930	2,050	2,170	2,290	2,410	2,520	2,710	2,770	3,010	3,310	3,610	3,910	4,210	4,520	4,820	5,420	6,020							
48	1,260	1,380	1,510	1,630	1,760	1,880	2,010	2,140	2,260	2,390	2,510	2,630	2,820	2,890	3,140	3,460	3,770	4,080	4,400	4,710	5,030	5,660								
50	1,310	1,440	1,570	1,700	1,830	1,960	2,090	2,220	2,350	2,490	2,620	2,740	2,940	3,010	3,270	3,600	3,930	4,250	4,580	4,910	5,240	5,890								
52	1,360	1,500	1,630	1,770	1,910	2,040	2,180	2,310	2,440	2,590	2,720	2,850	3,050	3,130	3,400	3,740	4,080	4,420	4,760	5,100	5,440	6,130								
54	1,415	1,560	1,700	1,840	1,980	2,120	2,260	2,400	2,540	2,690	2,830	2,960	3,170	3,250	3,530	3,890	4,240	4,600	4,950	5,300	5,660									
56	1,470	1,610	1,760	1,910	2,050	2,200	2,350	2,490	2,630	2,790	2,930	3,070	3,280	3,370	3,660	4,030	4,400	4,760	5,130	5,500	5,860									
58	1,520	1,670	1,820	1,970	2,130	2,280	2,430	2,580	2,720	2,880	3,040	3,100	3,400	3,490	3,800	4,180	4,560	4,940	5,320	5,690	6,070									
60	1,570	1,730	1,890	2,040	2,200	2,360	2,510	2,670	2,820	2,980	3,140	3,290	3,520	3,610	3,930	4,320	4,710	5,100	5,500	5,890										
66	1,730	1,900	2,070	2,250	2,420	2,590	2,760	2,940	3,100	3,280	3,460	3,620	3,860	3,970	4,320	4,750	5,180	5,620	6,050											
72	1,880	2,070	2,260	2,450	2,640	2,830	3,020	3,200	3,380	3,580	3,770	3,950	4,210	4,340	4,710	5,180	5,660	6,130												
78	2,040	2,250	2,450	2,650	2,860	3,060	3,270	3,470	3,670	3,880	4,080	4,280	4,550	4,700	5,100	5,620	6,120													
84	2,200	2,420	2,640	2,860	3,080	3,300	3,520	3,740	3,950	4,180	4,400	4,610	4,900	5,060	5,500	6,040														
90	2,360	2,590	2,830	3,660	3,300	3,530	3,770	4,010	4,230	4,480	4,710	4,940	5,240	5,420	5,900															
96	2,510	2,760	3,020	3,270	3,520	3,770	4,020	4,270	4,510	4,780	5,030	5,270	5,590	5,780																

Belt speed in ft. per min. is

$BS = 0.2618 \times D \times S$,

Where **D** = pulley diam. in inches and **S** = pulley r.p.m.

Pulley speeds selected are those nearest to synchronous speeds of alternating-current motors.

New York's worst power failure began at 4:16 P. M., Jan 15, when 60-cycle busbars at Hell Gate Station shorted and started a train of power failures. You read the scareheads in the newspapers, now .....

N. Y. Edison Tells WHAT REALLY HAPPENED AT HELL GATE

THE trouble which occurred on the New York Edison system Jan. 15, started at about 4:16 p. m., with the development of a ground fault on one of the sections of the 60-cycle, 13-kv. bus at Hell Gate station. At the time when this ground occurred, the station was being operated with two segregated bus sections, one the main bus and the other the auxiliary bus. Ties coming into the station from the Niagara Hudson system and from Sherman Creek, Waterside and Hudson Ave. stations of the New York Edison system, were distributed between the two independent bus sections. A 160,000-kw. unit and a 40,000-kw. unit were operating on the main bus, with the neutral of the generator of the high-pressure element of the 160,000-kw. unit connected solidly to ground. Another 160,000-kw. unit and a 35,000-kw. frequency changer were in service on the auxiliary bus, and the neutral of the high-pressure element of the 160,000-kw. unit was solidly grounded.

Whether the initial ground fault, which occurred on C phase, developed first on the main bus or the auxiliary bus is not known—in any event it communicated immediately to the other bus. Indications are that the fault arose first on the main bus. No statement as to the probable cause or circumstances of the first ground has been made, and the force of the ground current, together with the flames, wrecked the bus section and destroyed whatever evidence there may have been as to the producing cause of the fault.

All incoming 60-cycle ties and the frequency changer were disconnected from the buses automatically. The two 160,000-kw. units continued to feed ground current into the fault; and before the machines could be disconnected manually from the bus, the neutral grounding connections from the generators had burned off. Oil from the switches which connected the neutrals to the ground bus caught fire, and the ensuing conflagration damaged the neutral connections of two other 60-cycle generators.

In the meantime, before the trouble was cleared, a fault had developed on A phase at another part of the auxiliary bus, located on the same floor but isolated from the point of the original fault by an intervening storeroom and several fire walls. This fault on A phase damaged the connections on one Niagara-Hudson and one Hudson Ave. tie so that they could not be restored to service.

All generators were disconnected from the buses by the operator, thus clearing the faults and interrupting all 60-cycle supply from the Hell Gate station.

The 60-cycle distribution system normally supplied from Hell Gate is divided into the following zones: the County of Westchester, the Borough of Queens, the Borough of Bronx, and the Borough of Manhattan, which is further subbdivided into three districts. These Manhattan districts are Battery to 59th St., 59th St. to 129th St., and 129th St. to Harlem River.

Service to Westchester County was maintained by the Niagara-Hudson ties. A brief interruption in Mount Vernon occurred as a result of local trouble in Mount Vernon substation. Service to Queens was maintained without interruption from Hudson Ave. station. Service to about half of the Bronx and to Manhattan north of 129th St. was maintained from Sherman Creek Sta. This station and the connected distribution system were badly overloaded, causing low-voltage service. 60-cycle service to the Manhattan district between 59th St. and 129th St., comprising about half the total load, was completely interrupted; the remaining portion was unaffected, since it was supplied by the d.c. system. Service to the Manhattan district between the Battery and 59th St. was maintained from Hudson Ave. and Waterside.

Undamaged portions of the bus structure at Hell Gate were promptly re-energized by tie feeders to the Niagara-Hudson system, and to Hudson Ave. and Waterside stations. Distribution feeders from the re-energized portion of the Hell Gate bus were restored to service. Overloaded conditions on Sherman Creek were thereby relieved and normal service restored to the Bronx and Manhattan north of 129th St., except in a few local areas where overloaded transformers and secondary mains had been damaged. The above operations had been completed in about one hour's time.

Distribution feeders restored to Manhattan between 59th St. and 129th St. were insufficient in number, and serious overload resulted on the feeders, distribution transformers and secondary mains. Numerous distribution transformer fuses blew out, resulting in continuing the interruption to a major portion of this district. Service was restored by sub-division of the secondary mains in the district and successively re-energizing the sub-divided areas by simultaneous replacement of transformer fuses, the load in the areas having been reduced by opening a part of the customers' service switches. Shortly after midnight, substantially normal service had been restored to those customers whose service switches had not been opened, except in a few local areas where overloaded transformers and secondary mains had been damaged. The open service switches were progressively closed, and by 3:00 a. m. conditions in the district were generally normal.

In the meantime, emergency repairs to the damaged portions of the Hell Gate bus were in progress, with additional distribution feeders being restored to service from time to time. A majority of the feeders were energized by 10:30 p. m., and substantially normal conditions were restored by 3:00 a. m. Further inspection in the station had disclosed that the turbo-generators were undamaged. Repairs to the neutral connections were made, and the machines were restored to operation as required. Hell-Gate operators were hampered throughout the trouble on account of numerous failures of the control and indication circuits which were found to have been caused by the fault current passing over them.

In addition to the interruption of service to general consumers, the disturbance affected the supply of the Independent Subway system of the City of New York. Although high-tension supply to the subway system was generally maintained, train-signal system and miscellaneous auxiliary services are supplied exclusively from the network distribution system, and hence were subject to the conditions of interruption which affected the general consumers in the various districts. This caused the Independent Subway system to suspend passenger service until 7:30 p. m.

In the district between 59th St. and 129th St. in Manhattan, where the major interruption occurred, there were some 40,000 customers involved, compared to a total of about 2,000,000 supplied by the New York Edison system.

A.S.H.V.E. REPORT HELD OVER

The report of the Chicago meeting of the American Society of Heating & Ventilating Engineers, scheduled for publication on this page, has been held over until March POWER to permit publication of the last-minute statement on the Hell Gate Station failure.

MIDWINTER A.I.E.E. CONVENTION

Features: Improved method of starting synchronous motors, 300-kva. electron tube frequency changer that can also be used as a rectifier, new type of vibrating rectifier of large capacity, automatic control of rectifiers, supervisory control of pumping plants, remote metering and control and photo-electric cell applications

HELD in the Engineering Societies Bldg., New York, N. Y., Jan. 28 to 31, the American Institute of Electrical Engineers' winter convention included many technical and social features on its program. The convention was opened by awarding the Mascart Medal for 1936, of the Société Francaise des Electriciens to Dr. A. E. Kennelly, professor-emeritus of electrical engineering, Harvard University and Massachusetts Institute of Technology. On Tuesday evening the Edison Medal was presented to Dr. Lewis B. Stillwell for distinguished engineering achievements and his pioneer work in generation, distribution and utilization of electrical energy.

The technical program comprised thirteen sessions, at which 58 papers were presented.

Angle-Switching

Performance of a synchronous motor during pulling-into-step period depends upon the relative angular position between the field poles and the flux in the air gap at the time excitation voltage is applied to the slip rings. Control of the time excitation voltage is applied with respect to angular relation is called angle switching, and was the subject of a paper by C. C. Shutt and J. W. Dawson, Westinghouse Electric & Manufacturing Co. For angle switching, motor and its control are standard, with addition of a small inductor generator and an electronic-tube panel. The generator is mounted on the motor shaft or spider and is without brushes, rings or commutator and supplys energy required for the tube grid circuit. The tube panel, in a small steel cabinet, may be installed on the main control panel.

An increase in pull-in torque up to 40% with a given starting current is one of the advantages of angle switching. Smoother synchronizing is another important advantage obtained with angle switching. By selecting the correct angle at which field should be applied, pull-in can be accomplished, with a minimum of mechanical shock to the connected load. An example of this is found in a cement mill where it was required to reduce to a minimum the torque oscillation transmitted to gears connecting 800- and 900-hp. high-speed synchronous motors to tube mills. By angle switching, torque which produces mechanical oscillation during pull-in is kept to a minimum.

Another application of angle switching is where two shafts are driven by separate synchronous motors of the same speed, so synchronized that the shafts will have a fixed angular relation. By means of a modified angle switching equipment it is possible to start and synchronize one motor in a normal manner. Then any number of other motors can be started and pulled into step so that they will run at a predetermined displacement with respect to the first motor.

Such an application has been made at the new Kansas-City Municipal Auditorium. Four 400-hp., 225-r.p.m. synchronous motors drive reciprocating compressors for air-conditioning equipment. It was required that the compressors operate with their cranks out of phase to reduce total current pulsation, to prevent light flicker or interference with operation of other connected apparatus. One of these motors and the control equipment for two are shown in the large photo.

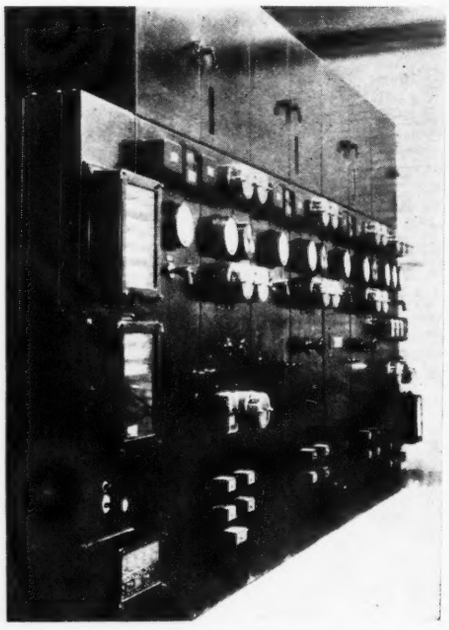
Static Frequency Changer

Another interesting development, a static thermionic-tube frequency changer, was described by A. Schmidt, Jr., and R. C. Griffith, General Electric Co. This unit will for a time operate as a frequency changer and later will be changed for operation as an a.c. to d.c. rectifier. At Camden, N. J., the New York Ship Building Corporation generates its own power for a load consisting principally of 60-cycle and direct-current motors. It was desired to replace by more efficient equipment an engine-driven generator supplying power to a few hundred horsepower or 25-cycle motor. During the next few years it was anticipated that these motors would be replaced gradually by 60-cycle machines and there would be no further need for the 25-cycle generating equipment. Demand for direct-current power is considerably less than the capacity of the smallest generator unit in the plant, during certain periods of the week so that an efficient source of direct-current power would return an appreciable saving.

To supply this load a static frequency changer was chosen, which uses twelve grid-control mercury-vapor tubes and delivers 300 kva. at 220-volt, two-phase, 25-cycle power, from a 2,300-volt, three-phase, 60-cycle source. When 25-cycle power is no longer required, the 60-cycle transformer winding will be reconnected for a lower secondary voltage, a portion of the control equipment will be disconnected, and the apparatus will be available as a rectifier with an output of 300 kw., 250 volts direct-current.

Rectifiers

Until recently vibrating-type rectifiers have been built in very small capacity. A new design has been developed by G. T. Southgate, consulting engineer, and was described in a paper, "Vibratorily Commutated Stationary Conversion." This unit can be built in sizes up to 400 amp. of contact capacity, and instead of having one contact, as on the conventional type, it has a multiplicity of them arranged in a circle at each end of the unit. These contacts are mounted on the ends of reeds, which are caused to vibrate electromagnetically. Surrounding the vibratory commutating system is a special transformer with a closed primary and secondary winding. These windings are subdivided into many phases corresponding to the coils of a ring armature. The traveling magnetic field produced in this winding, when excited by a polyphase current, actuates the vibrating contact in synchronism with the travel of flux polarity in the respective transformer coil to rectify the alternating current.



Switchboard for supervisory control of waterworks pumping station

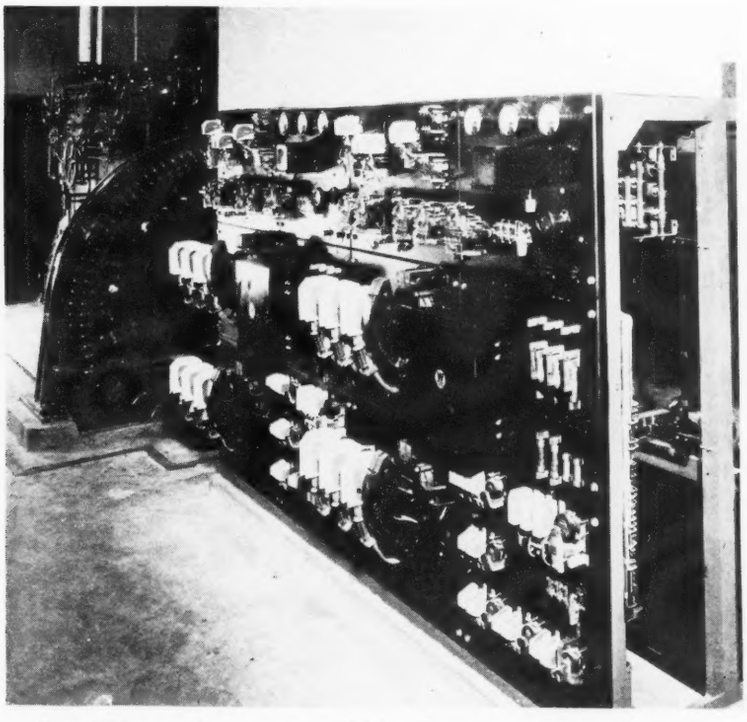
A review of present day practice in automatic control for steel tank mercury arc rectifiers was presented by H. Bany of the General Electric Co., and M. E. Reagan, Westinghouse Electric & Manufacturing Co., in a paper, "Automatic Control for Mercury-Arc Rectifiers." Automatic control for steel tank mercury-arc rectifiers is considered under two main divisions: one, control for switching equipment, and the other, control of the unit auxiliaries, such as tank heaters, anode heaters, vacuum control and protective equipment, arc ignition and excitation, cooling tanks and circulation pumps. Most mercury-arc rectifier equipment in this country has been furnished for unattended installations. Those that are not fully unattended have generally been arranged for partial automatic control, with full automatic operation of the rectifier auxliaries. With these installations the attendant merely closes or recloses the alternating-current and direct-current circuits when required and receives an alarm upon the occurrence of any abnormal conditions.

It is the authors' opinion that due principally to future development possibilities in the rectifier itself, it may be expected that certain present-day switching and protective arrangements may become modified or augmented to suit the change. The future application of voltage control by anode grids

FEATURES NEW EQUIPMENT

and the increased use of rectifiers as inverters and as frequency changers should result in a gradual simplification of the present control methods for these less common rectifier applications. However, a further simplification of this rectifier control and protective requirements appears to offer the best promise of simpler and less expensive automatic rectifier installations.

Application of supervisory control equipment to electric pump drives on municipal water-works systems results not only in greatly improved operation, but also in a reduction of operating costs. Existing water-works systems may be modernized and many improvements secured by the application of various types of electrical equipment. As an illustration of the benefits which may be obtained. S. A. Canariis described the modernization of the City of Pittsburgh water-works system, where electric operation of



Four 440-hp. synchronous motors driving Freon compressors equipped for angle switch at starting to dampen current fluctuations

pumps together with supervisory control, remote metering, and remote indication are now used.

Of the City's nine pumping stations, three are attended electrically operated plants, two are full automatic electrically operated stations, and one the Saline pumping station, electrically operated, but also controlled over a two-wire supervisory control system from the attended Herron-Hill pumping station approximately two miles distant. The operator in Herron Hill station can start any one of the three pumps in Saline plant at will, and get an indication of their operation. In addition, the despatcher has indications of adequate suction pressure, voltage on each phase of the power supply to the station, and a continuous indication of the pumping-station discharge pressure. If a pump trips off the line the dispatcher gets a signal immediately and an alarm sounds.

Before the Georgia Power Co.'s system became a part of a large interconnected system, remote metering and automatic load control were regarded as refinements. The problem changed materially when operating as a part of a interconnected system where synchronism is maintained between about 750,000 kw. generating capacity south of Tennessee, and a much greater capacity north of Georgia through one 110,000-volt interconnection with Tennessee Electric Power Co.

To maintain even an approximate load schedule on this line, when in parallel with the system to the north, required almost continuous use of the telephones. Even then the load would frequently get beyond control during change periods. J. T. Logan, of Georgia Power Co., described equipment installed to overcome this. Remote metering and automatic control equipment has surpassed all expectations. Releasing the telephone lines for other use has more than paid for the installation. More than 200 telephone calls daily have been eliminated between the despatcher and the Lindale substation operator, and a like number between the despatcher's office and various generating plants.

The reliable capacity of the Georgia-Tennessee 110,000-volt high line has been increased by at least 50 per cent. Schedules of 45,000 kw. over this line are now made with less hesitancy than a 30,000-kw. unit was previously scheduled, and interruptions from load drifts have been practically eliminated. After nine months' experience with this equipment maintenance cost is negligible.

An investigation of the effects of polarity and current density electrical brush wear was reported in a paper, "Electrical Brush Wear," by V. P. Hessler, Iowa State College. These tests show that rate of wear of positive carbon brushes is low, and is independent of current density below a critical value, which varies with different brush materials. Rate of wear of negative carbon brushes is greater than that of positive, and is proportional to current density below a certain value. Above this value there is a decrease in the rate of wear with increasing current density, followed usually by a sudden increase in the rate of wear as the current density is increased to excessive values.

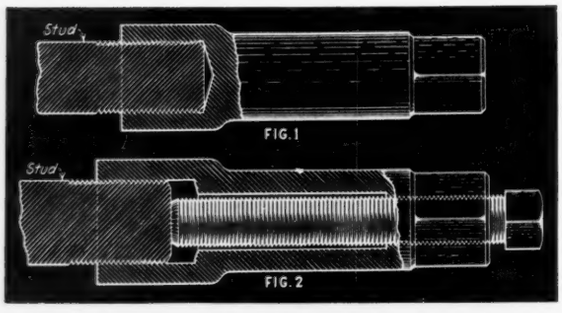
Wear of positive metallic brushes is approximately proportional to current density, but with negative metallic brushes it is practically independent of current density, to values considerably in excess of normal current density. Wear of both positive and negative copper impregnated brushes is approximately proportional to current density.

In general, there is no consistent relation between the contact potential drop and rate of wear of electrical brushes. The copper impregnated brush, however, is an exception. In all tests made on it, the configurations of the constant drop curve and the corresponding rate-of-wear curve were similar. The pronounced polarity effect and the complex nature of the curve for the negative carbon brushes indicates that the rate of wear is connected intimately with the conduction of current across the contact. Material might be removed from the brush face by abrasion, combustion, or disintegration. The very low rate of wear at zero current shows that ordinary abrasion accounts for only a small portion of total wear. Combustion might account for a small portion of the wear. Apparently current flow across the contact produces a disintegration of the brush surface. This might be caused by thermal expansion resulting from high current density at the points of contact between the brush and ring. It is not apparent how this action would explain the difference between the rates of positive- and negative-brush wear. More qualitative data, involving other factors of brush wear, will have to be obtained before the complete explanation of brush wear is found.

Photo-Electric Cells

A photo-electric cell of the dry-disc type, consisting of a light-sensitive disc, and not requiring any vacuum or liquid, was developed a few years ago and has proved to be a very useful device. Characteristics of one type of dry-disc photo-electric cell were described in a paper, "Application of a Photo-Electric Cell," by Anthony H. Lamb, Weston Electric Instrument Corporation, and applications of this cell given. Among the uses for this cell are illumination and exposure meters, the control of automatic weighing circuits for smoke alarms and for the control of sludge level at sewage-disposal plants.

PRACTICAL AIDS TO OPERATION



Tool for Installing Threaded Studs

TO OVERCOME the disadvantages of the stud-driving tool, Fig. 1, I designed and made the type in Fig. 2. The body of the tool is bored through completely. Part of this hole at its top end is threaded for square-headed screw, which is screwed into the body until it rests on the stud as in the figure. About two-thirds of the lower portion of the hole is bored to give a clearance for the screw. The end of the screw is made square, chamfered and hardened, so that it will stand up under pressure against the stud.

To use the tool, the stud is screwed into place and the screw tightened against it as shown in Fig. 2. Care should be taken not to let the thread on the screw jam in the tool socket or at its lower end. When the stud is locked in place in the tool it is screwed into place with a wrench on the squared end of the socket.

This little stunt effectively prevents marring or bruising stud ends and damaging threads. I have found it particularly useful and a time saver when studding boilers. It, of course, has general application wherever threaded studs are to be placed.

Baildon, England — W. M. HALLIDAY

Curved Versus Flat Bridge-Walls

RECENTLY I overheard an argument between two millwrights about bridge-walls. They were looking over a furnace recently completed and equipped with a level bridge-wall when the discussion started.

"The top of a bridge-wall ought to come up within 8 in. of the boiler at every point," said Jones.

"What's your idea for that?" asked Smith.

"A curved bridge-wall makes the flames hug the boiler at all points," Jones answered.

"Pshaw! man; why put a damper in the furnace? Better be thinking about a 'blower' to force the draft," returned Smith.

"You want to heat the tubes and allow the shell to remain cold, then, do you?" snorted Jones.

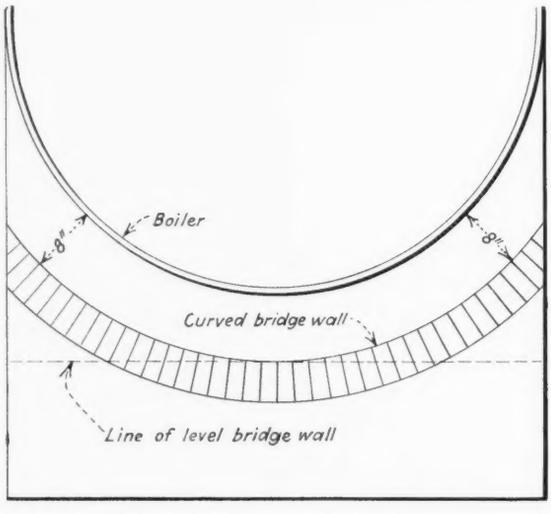
"I believe in heating the shell, too, but there's a lot of bunk to this bridge-wall stuff. Why, man, at most of the smaller sawmills I look over in my work, I find the bridge-walls torn down. The masons always put in one, but the fireman usually tears it down unintentionally in firing with waste slabs or other solid material. When I ask about their dilapidated bridge-wall, they usually tell me the furnace does as well or better without it and consequently they don't care to rebuild it. I like a spacious furnace, wherein the fire can burn brilliantly, instead of being choked or smothered. I find too many low settings at sawmills, and I don't see any sense in making the furnaces more 'stuffy' by adding such a bridge-wall as you recommend." This was Smith's reply.

"Well, you may be right; but I believe in making the flames hug the boiler shell, whether the furnace is spacious or cramped," said Jones.

"Your curved bridge-wall might be the thing in a spacious furnace where concentrated fuels such as gas, coal, etc., are used; but I can hardly tolerate even a level bridge-wall in a cramped wood-burning furnace," Smith hushed.

"I agree to disagree," Jones concluded.

I didn't enter into the discussion, but I prefer to take a stand about midway between the two men who gave their ideas. It seems to me that any advantage gained by forcing the flames against the shell with a curved bridge-wall, as in



the figure, might be outweighed (or at least balanced) by the tendency of such a wall to check the draft, especially at the sides of the furnace. I want to explain, too, that this discussion centers about wood-burning furnaces. However, it is doubtful if anyone should engage in such hair-splitting, except trained engineers. Let's hear from one who knows.

McCool, Miss. — BUNYAN KENNEDY

Lack of Common Sense Is Expensive

A NUMBER of years ago, a textile mill was built having a boiler room built integral with the building. The steam generating equipment included two vertical, fire-tube boilers. While sufficient headroom was available for normal operating conditions, the original design had made provisions for a more or less temporary flooring above the boilers. This construction was a foresight, in anticipation of difficulty when renewing boiler tubes in the future.

A few years ago the ownership of the mill changed and

the new management, seeing vacant floor space over the boilers, braced this flooring and installed heavy machinery. Last year it was discovered that, corrosion, pitting, and erosion had reduced the thickness of the boiler tubes to such an extent that they required renewing. The heavy machinery overhead was dismantled and moved, and the reinforced flooring was taken up over the boilers, to make room for the retubing.

Assuming that the floor space over the boilers was so valuable that its permanent use was warranted, installing machinery there can be accepted as practicable. But, space in the boiler room was available to lay a boiler on its side upon the floor, with the top end facing large doors. The tubes could then be easily removed and replaced through the door opening at over $400 less cost than for the method used in retubing the boilers. This loss is a definite example of lack of intelligent planning.

Philadelphia, Pa. CHARLES A. ARMSTRONG

Corrects Erratic Operation of Elevator Brake

ON A freight elevator operated by a three-phase motor, with a single-phase brake connected across two of the motor terminals, trouble was experienced with the brake not releasing properly. This caused a shock on the car and at times opened the over-load relay contacts. At first the trouble was thought to be caused by some mechanical defect. To check this the brake magnet was removed from its oil tank, but was found in good condition.

To check the brake's electrical conditions its connections were transferred from the motor directly to the line with a 0-10-amp. ammeter in series. Under these conditions the brake functioned correctly with a current of 2.25 amp. in its coil.

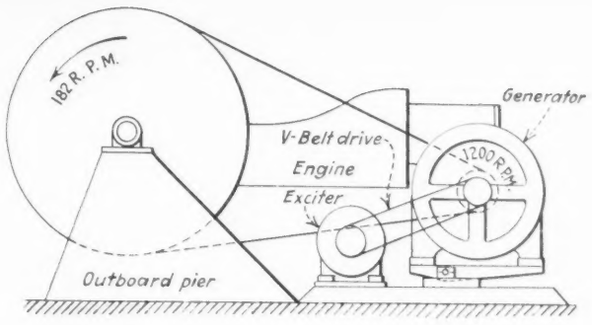
The brake-coil connections were then restored to normal, the motor leads disconnected and the brake operated by closing and opening the main contactor switch. Under these conditions operation of the brake was erratic, the cause of which was found to be a high-resistance deposit on the switch contacts. These contacts were cleaned and the pressure between their surfaces increased. Since this was done brake operation has been normal.

Oakland, Cal. A. L. JONES

Saves $85 per Month on $800 Investment

SAVINGS can be made in the power bill, even though the the plant is a small one. At a laundry, the electric power bill averaged $100 per month, while relatively large quantities of live steam as well as engine exhaust were used in the open heater to heat water for the washers. This condition suggested generating power with the steam engine so as to replace live steam for heating with exhaust. It was desired to drive a generator with the existing engine, which also drives the lineshafting, to keep the added investment as low as possible.

Due to lack of room, the only place for the generator was alongside the cylinder of the engine, driving it from the flywheel with a belt, using a pivoted motor base to maintain proper tension in the belt. The only changes made to the engine was a slight increase in speed, and to reinforce the outboard bearing pier.



The generator, rated at 30 kw., 220 volts, 3 phase, has a 10-in. pulley, and the engine flywheel diameter is 66 in., center to center distance being 8 ft. The exciter is driven from the generator by two V-belts, this center distance being three feet. The line shaft is driven from a 26-in. pulley located between the flywheel and outboard bearing on the engine shaft.

For convenience, some of the lineshaft load was motored and transferring to the generator. When carrying full load the flat belt and V-belts run perfectly. The unit has now run almost three years without any trouble, except the usual routine maintenance.

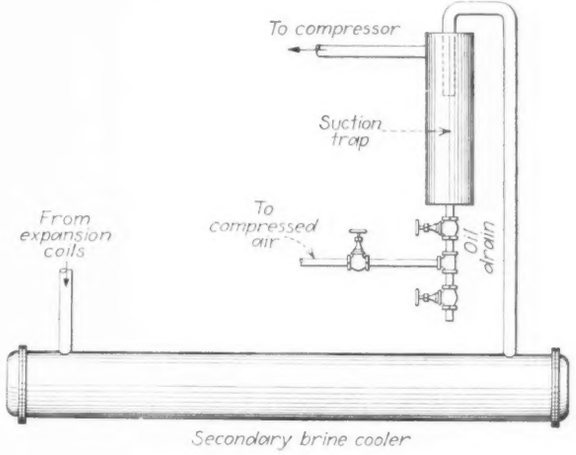
As no exhaust steam goes to the atmosphere and live steam has to be added for heating water in the winter, the plant is generating power at very low cost. The savings have been approximately $85 a month, and the installation cost $800.

Milwaukee, Wis. LAWRENCE M. LARSON

Cleans Suction Trap With Compressed Air

ONE day the oil drain became plugged on the suction trap located after the secondary brine cooler on our refrigerating system. This occurred during the hot weather when the plant could not be shut down to pump out that part of the system and disconnect the piping. First consideration was to connect a steam line to the oil drain and blow steam through it. This method no doubt would have cleaned the drain, but it would have caused trouble from condensed steam mixing with the ammonia and freezing in the expansion coils.

Compressed air was decided on as this would require purging the system only. A compressed-air line was connected as in the figure. After blowing air at 90 lb. through the drain for a short time the air valve was closed and the



drain opened to atmosphere. Dirt that had accumulated in the nipple and valve at the bottom of the trap was then readily blown out. After a few hour's run the condenser was purged and the plant did not have to be shut down to correct the trouble.

Cleveland, O. THOMAS C. BROCK

Tinning Dipper Made From Pipe Fittings

A TOOL, which I made from pipe fittings, can be advantageously used for tinning ends of wires that protrude downward from overhead outlets, is shown in the figure. A reservoir is formed in the top end of the device, holds the molten solder, and one need only raise the tool in a vertical position to immerse the wire ends in the solder.

To make the tool a coupling *B* was screwed onto an 8-in. piece of iron pipe. A small metal disk *C* turned to a diameter that would slip into the coupling and lie on the pipe end was welded into position. Enough weld metal was deposited to make a smoothly formed reservoir in the top of the tool.

A handle *E* was turned from hardwood and made with an extension that would fit the pipe end snugly. For melting the solder in the reservoir, the tool can be held in a vertical position while playing the flame of a blowtorch upon it.

Peoria, Ill. JOHN E. HYLER

Uses Ice to Lower Electrical Conduits

THIS problem is somewhat outside the power plant, but the means used may prove useful when handling certain kinds of large equipment. Early last year, in Brooklyn, N. Y., the Bureau of Highways Engineers decided to lower Flatbush Ave. approximately 3 ft. This required that The Brooklyn Edison Co. lower its duct system by an equal amount. It was proposed that the structure could be lowered as a unit by using cakes of ice.

A normal surface pressure of 75 lb. per sq.in. causes ice to fail in shear along a plane at 45 deg. to the normal. The duct line and cables weighed 250 lb. per ft. To avoid abnormal stresses in the duct line it was decided that ice supports would be necessary at 6-ft. intervals. This gave a section weighing 1,500 lb. to be supported by each ice block. If a normal stress of 40 lb. per sq.in. was allowable, a section of 37.5 sq.in. for bearing surface of the ice was the minimum.

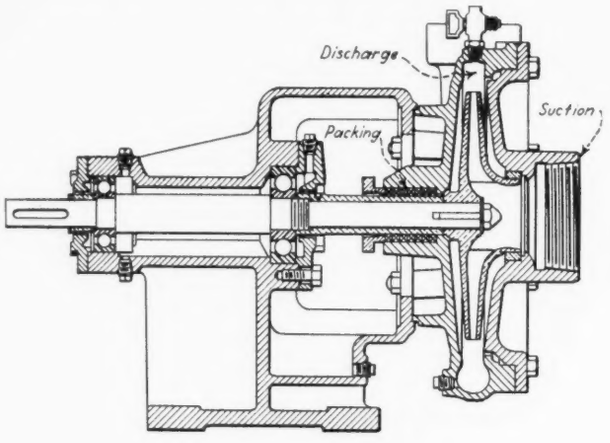
Commercial cakes of ice have dimensions of 14 x 30 x 48 in. It was decided to cut these cakes in half, thus making a 24-in. supporting block for the duct line and a bearing surface of 420 sq.in., which decreased as the ice melted. This method was tried on a section of the duct line about 300 ft. long and worked so well that the remainder of the structure was lowered in the same manner, taking the sections between manholes, which averaged from 300 to 500 ft. Actual work was done as follows:

1. The section of duct line was exposed for its entire length and cut loose from the end manholes.
2. Holes large enough to contain the ice blocks were dug under the line at 6-ft. intervals.
3. Ice was placed under the duct line and shimmed up to give support.
4. The remainder of the earth was then removed and the line left entirely supported on the ice blocks.

Sectional area of the ice blocks was preserved as much as possible by piling earth around them for insulation. When melting, the ice assumed the shape of a truncated pyramid with the smaller base in contact with the duct. The line was kept under constant inspection and was braced where necessary to prevent lateral tilting.

It generally required about 72 hours for the ice to melt down to a sectional area approaching the minimum and in this time the duct line itself had been lowered about 19 in. Where more lowering was needed, the process was repeated.

Brooklyn, N. Y. BROOKLYN EDISON CO., INC.



Change in Pump Type Stops Shaft Wear

A CHEMICAL company needed a pump to circulate liquid from a tank through a process. Bids were asked from several pump companies on a pump for 50 g.p.m. against 96-ft. total head at 1,750 r.p.m. On the basis of information given in the customer's inquiry, the manufacturer quoted on a single-stage, single-suction pump similar to the type illustrated. The pump was purchased and installed, and a lot of stuffing-box trouble developed. From the figure it will be seen that total discharge pressure acts on the stuffing box. In an attempt to stop the loss of fluid through the stuffing box, its packing gland was kept so tight that the shaft sleeve wore rapidly, and had to be replaced every few weeks.

Correction of the difficulty was put up to the pump manufacturer. He arranged to replace the old pump with a small double-suction unit so that stuffing-box pressure was only the 6-ft. head from the suction tank. This was easy for the stuffing box, and the new pump has been in service for over a year with no replacements of shaft sleeves being required.

Pump manufacturers have accumulated considerably more experience with pumping problems than the average user of this equipment. It would be to the user's advantage to avail himself of this, thus putting responsibility for proper equipment up to the one who is to supply it.

New York, N. Y. FRANK A. KRISTAL

CURRENT COMMENT

Wire-Rope for Operation of Combustion Control

THE article "Operates Fuel Valve From Damper Regulator," in November, 1935, *Power,* by C. D. Hudson, was of interest to me as I often have to design equipment for controlling oil-burner valves from a damper regulator. Presumably Mr. Hudson operates the valve with a steel-wire rope. It may be helpful to point out that some kinds of wire rope are not suitable for control connections. ¼-in. wire rope generally has ample tensile strength, but unless it is very flexible it will break in a short time due to continuous bending over the pulleys.

I have found that tiller rope, which is specially designed for service of this kind, is most satisfactory. Light chain is not suitable for control purposes. Experience has shown that each link has a slight spring in it which, multiplied by the number of links in a long chain, makes the control very erratic.

Bloomfield, N.J. JAMES O. G. GIBBONS
Consulting Engineer

Formula for Flow Velocity In a Pipeline

ON PAGE 574, November, 1935, *Power,* Frank A. Kristal gives formulas for determining the velocity in feet per second for a given flow and size of pipe. Being in the pump business for some thirty years, we take the liberty of presenting an abbreviated formula by which to calculate the velocity, namely:

$$V = \frac{G.P.M. \times 0.41}{d^2}$$

In this formula V equals velocity in feet per second and d is the diameter of pipe in inches.

Stockton, Calif. F. KWAST
Chief Engineer
Sterling Pump Corp.

"Humming" of Boilers

THE strange phenomenon, known as "humming" of boilers, seems to be extremely scarce on this side of the Atlantic, but knowing the ramifications of your journal *Power,* which goes all over the U.S.A. (and all over England), I was wondering if any of your readers could advance any technical explanation of this "humming." I have personally conducted several tests, in order to trace the origin of these audible low-frequency vibrations, so far without success. I would therefore be grateful for the views of your readers on this problem.

Manchester, England
FREDERICK W. JOHNS

EDITORIAL NOTE: *The following brief summary of the comments published by Mr. Johns, in the September, 1935, number of "Engineering and Boiler House Review," will assist readers who may care to answer this question.*—EDITOR.

Atmospheric and other conditions affect this low-frequency humming. My own experience is limited to an old plant containing 6 B. & W. boilers.

The primary cause of the humming seems to be the effect of cold air (not over 55 deg. F.) admitted under the grate, and a consequent reed effect set up between the links of the grate. Once started, this seems to build up until the boiler house is like the sound chamber of a church organ, until the fireman eases down the induced-draft fan or admits secondary air through the fire door.

A further contributary cause seems to be that the low-frequency oscillations are in complete resonance with the boiler-feed pump, if it is of the centrifugal type, and the sound can be regulated to a more or less musical note by manipulation of the speed of the pump. However, humming has also been obtained where reciprocating pumps are used.

As far as the chimney is concerned, the humming seems to be dependent upon the speed of the flue gas and its consequent temperature.

Opening the ash-pit doors admits a large quantity of cool air, and unless this air is heated before it reaches the combustion surface, reed effect will be produced, and the vibrations become audible again. Usually, however, air admitted in this manner is heated by radiation before reaching the grate and assists combustion, provided that the dumping bars at the back of the grate are closed. Otherwise, an excess of cool air will be drawn in, and the above effect will occur.

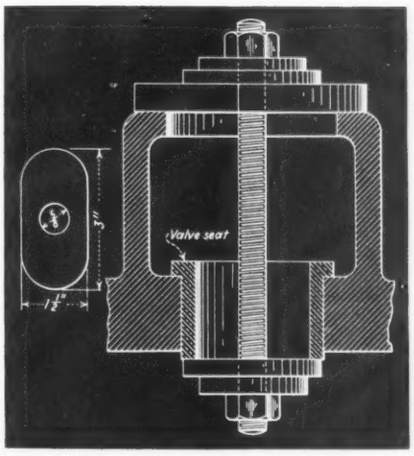
Feedwater temperature also appears to play its part. Humming is more frequent with low temperatures than with high. Humming is avoided if combustion air is controlled in a closed-grate system or a system using secondary air (preheated), but in this case ash pits are open and the induced-draft fan is the only means of controlling the air.

An Easily Made Valve-Seat Puller

THE valve-seat puller described by Burton W. Wheeler in October, 1935, *Power,* appears to be effective, but its construciton is complicated. Many plants are small and do not have a machine shop in which to make special tools, and the engineer has to use simple methods. The valve-seat puller in the diagram can be made by any engineer from materials easily obtainable. From a bar of 0.5x1.5-in. mild steel cut a number of strips varying in length from about 2½ in. to 6 in. long, in ½-in. steps and round their ends on an emery wheel or with a file.

Drill a ⅝-in. hole in the center of each strip. Use a piece of 1x2-in. steel about 8 in. long, with a ⅝-in. hole through it as a strongback. Thread a ⅝-in. steel rod about 12 in. long its entire length. An assortment of washers and two ⅝-in. nuts completes the equipment.

To draw the valve seat, select a strip that fits and also use one of a size shorter as an



added stiffener. Place the strips below the valve seat and hold them in place and assemble the puller as in the diagram. Tighten up the top nut and, if the seat is difficult to start, give the strongback several smart blows with a hammer, keeping tension on the rod.

Passaic, N. J. MARK BELL

Cutting In a Boiler

I HAVE read with interest the articles on "Steam Plant Errors" by Frank H. Browning in recent issues of *Power* and have heard much favorable comment on them. They are of particular interest because of the big drive to have engineers' license laws passed in every state.

However, I cannot agree altogether with Mr. Browning's method of cutting in a boiler, as described in the October, 1935, *Power.* I can see the advantage of cutting it in at a lower pressure than is carried on the header if the boiler lead to the header is not properly drained, or supplied with valves that will drain this steam lead while warming it up. But in such a case the proper solution would be to install the necessary drain valves.

I thoroughly agree with R. A. Hafford's statement in December *Power* that Mr. Browning's article is misleading to young firemen. This might also apply to other power-house operators, as nearly all modern power houses use a non-return stop valve in the main steam connection next to the boiler. This steam lead usually connects into a large steam header through a stop valve with one or more suitable drain valves and a small bypass line for warming this steam lead and draining the condensate preparatory to cutting a boiler in service. One of the drain valves is as near the seat of the stop valve as possible. This drain is gradually closed as the steam lead warms up and is left cracked until the stop valve to the steam header is opened. This makes normal header pressure on the check or disk of the non-return valve. As the presure rises on the oncoming boiler the stern or stop on the non-return valve is raised. Drains or traps on the boiler side of the non-return valve are cut in and remove

any accumulated condensate on that side of the valve. As the pressure on the oncoming boiler reaches header pressure the pressure is equalized and as the pressure rises on the boiler, the disk opens and automatically cuts the boiler on the line, it taking its share of the load.

Any small amount of condensate that might be carried into the steam header is carried away by a trap connected on the bottom. The steam lines going to engines, turbines, and other equipment take dry steam from the top of the header. This system also insures against danger from foaming or priming while a boiler is in service.

The young fireman or engineer would probably run into this set-up in modern powerhouse work, and Mr. Browning's article or questioning would only tend to confuse him.

Non-return valves are recommended by the A.S.M.E. Code and also by boiler manufacturers. Some of their advantages are: 1. They provide a means for automatically cutting a boiler from the main line in the event of a tube failure, loss of a blow-off valve, or any other steam falure within the boiler. 2. They insure that no steam will back up into a dead boiler in which perhaps men are working, if some one should accidently open the stop valve to this boiler. 3. They provide an automatic means of cutting the boiler in service as described above. 4. They are economical as they permit unnecessary boilers to be easily cut out as the load drops off. Boilers without these valves are often permitted to run partly loaded or are dead-headed because of the inconvenienc of closing the stop valves manually. If the load varied often extra help might be required to take the unnecessary boilers out of service.

Waynesboro, Va. J. M. MYERS

Cutting In a Boiler

THE point raised by R. A. Hafford in December *Power* on cutting in boilers on the line is interesting. I have had some experience with various types of boilers up to 1,600 lb. pressure and wish to make a few comments on this matter.

If a boiler is cut in at somewhat higher than line pressure, there results an immediate flow of steam from the boiler through its steam main into the line. Condensation pocketed in stop valve chambers and other such places in the steam main will be carried along with the steam flow. It is possible that the amount of water carried along might be sufficient to cause serious damage.

On the other hand, if the oncoming boiler was at slightly lower than line pressure, flow of steam would be back into the boiler until pressures were equalized. This procedure would be definitely the better of the two.

The question of pocketed water cannot, however, be considered where non-return valves are used. If the boiler is cut in at higher than line pressure with a non-return valve, there is likely to be some shock to the valve disk depending upon the pressure differential. The boiler should be cut in at as near equal as possible to line pressure, or slightly lower, with this type of valve. After the steam valves are opened, the combustion rate should be increased, and the pressure gauges observed to determine operation of the non-return valve. If the pressure of the oncoming boiler does not increase above header pressure, it is known that the non-return valve has opened properly.

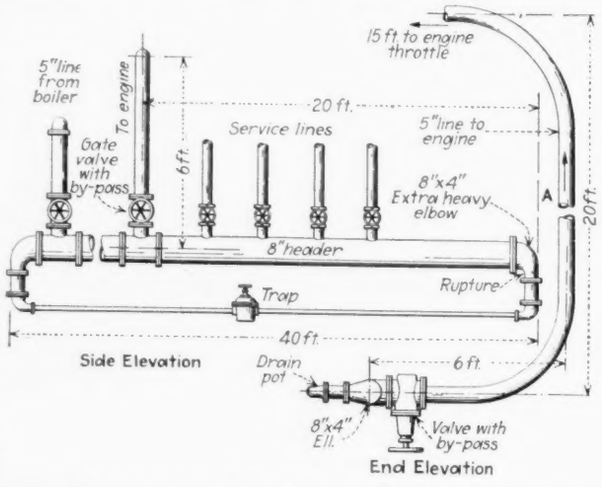
Attempting to cause the disk of the non-return valve to close suddenly by reverse flow should not be tried. If this disk opens, it is safe to assume it will close on emergencies and such an operation may cause such shock and line disturbance that it should be reserved only for emergencies.

Boston, Mass. HARRY M. SPRING

Difference in Expansion Caused Header Fitting to Fail

IN December *Power*, H. B. McDermid describes the failure of a fitting in a steam header, shown in the figure. One of two 8x4-in. reducing elbows connecting the ends of the header to drip pots ruptured at its smallest section. The two drip pots drain to a trap through a $\frac{3}{4}$-in. pipe that paralleled the header. If the diagram truly represents the piping layout, then there is no mystery about the accident.

Under any condition of operation, the temperature of the header would be several degrees higher than that of the drip line. But, as a result of careless manipulation of the valves, or the presence of cold water in the drip line due to failure of the trap, this temperature difference may be several hundred degrees. The expanding header would then put a very large tensile force in the $\frac{3}{4}$-in. pipe, which force multiplied by the perpendicular distance from the drain pipe to the fracture is the bending moment suffered by the fitting.



At the time of failure, steam pressure was 100 lb. gage and temperature 339 deg. F. If the condition alluded to existed, and the temperature difference betwen header and drip line became 200 deg. F., then the differential elongation of the piping would be about $200 \times 40 \times 12 \times 0.0000065 = 0.624$ in. If the drip line is $\frac{3}{4}$-in. standard pipe, its cross-section is about 0.34 sq.in. Assuming its length as 38 ft., the stress in the unthreaded portion, if stretched 0.624 in., is $(0.624 \times 30{,}000{,}000) \div (40 \times 12) = 39{,}000$ lb. per sq.in. The tension in the pipe is then $39{,}000 \times 0.34 = 13{,}250$ lb. If the perpendicular distance from the drip pipe to the fracture in the elbow is 18 in., the bending moment at that point is $13{,}250 \times 18 = 238{,}500$ in.-lb. The wall of the fitting at the fracture is about $\frac{5}{8}$ in. thick, so the section is a 4-in. inner, and a 5.25-in. outer, circle. The modulus of this section is $[0.098(5.25^4 - 4^4)] \div 5.25 = 9.37$ in.^{3}. Dividing the bending moment by the section modulus, we have $238{,}000 \div 9.37 = 25{,}400$ lb. per sq.in. for the fiber stress, which is the breaking stress of a high-grade cast iron.

Any of the factors assumed in the foregoing may be more or less than the actual ones. But one thing is certain; the elbows at the ends of the header had been subjected to many large forces during their life of 5 yr., and failure may have been the result of oft-repeated applications of forces much lower than found in the foregoing calculations. Had the connections to the trap been made with offsets, the necessary flexibility would have been obtained, and the elbows would have escaped the consequences of the obviously rigid arrangement.

Los Angeles, Calif. C. O. SANDSTROM

Wrong "Weak Link"

GEORGE EDWARDS, in your December, 1935, issue, under the heading "Weak Link," discusses a matter of great importance and offers valuable suggestions for the guidance of the engineer, but he only presents one side.

Some years ago, I recommended to a client that he install stokers under his boilers, and was met with the question, "Will they pay for themselves in one year, because if they will not I can spend the money for manufacturing equipment which will pay for itself in less time than that." The stokers were installed, but I am not sure it was best.

The important point to be kept in mind is that, in a large majority of cases, money available for improvements is strictly limited, and sometimes can only be raised by stretching the credit of the company to the limit.

Unfortunately, except perhaps in very large plants, the position of the operating engineer is such that it cannot be reasonably expected that the management will take him into its confidence, on the other hand, the management is often woefully ignorant of the particular problems of the power plant. It therefore appears to me that it is the management rather than the engineer who should be educated in these matters, as it is the only one who can see the problem as a whole.

The engineer himself, together with thousands of others, is very likely paying for a car on the installment plan, and it is a perfectly simple matter to show that this is a very expensive way of buying a car, but what is he to do if he hasn't got the money to pay cash? Well, the management may be in very much the same position, and if they say that there is no money available to make improvements, that statement may be perfectly true, and may not furnish a good excuse for looking for another boss.

Bloomfield, N. J. JAMES O. G. GIBBONS

THE ENGINEER'S BOOKSHELF

Steam Operation

STEAM PLANT OPERATION (1935)—*By E. B. Woodruff, Plant Engineer, and H. C. Lammers, Test Engineer, Union Gas & Electric Co. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. 368 pages, 6 x 8 in., 111 illustrations. Tables. Many definitions and problems, with answers. Cloth. Price $3.*

This book may best be described as a simple text book of stationary power engineering for the practical operating man. It is descriptive rather than mathematical, and shows in easy-to-read fashion how various pieces of power-plant equipment are constructed and operated. The book is suitable for home-study work or for classes in junior technical schools where an elementary presentation is desired. Most of this book can be mastered by an industrious man who has not gone beyond grammar school. Beyond question, there is a great field for a volume of this sort, particularly to help ambitious assistants and watch engineers who are coming up the line. Subjects covered include boilers, combustion, furnaces and combustion equipment, boiler accessories, steam engines, steam turbines, pumps, auxiliaries. The book stresses safe and economical operating methods, clearly outlining the rules of procedure to be followed.

Chemical Handbook

HANDBOOK OF CHEMISTRY & PHYSICS (20TH EDITION)—*Editor-in-Chief, Charles D. Hodgman, Associate Professor of Physics, Case School of Applied Science. Published by Chemical Rubber Publishing Co., Cleveland, Ohio. 1966 pages, 4 x 6¾ in. Flexible fabrikoid covers. Many tables. Price $6.00.*

New and revised material brings this standard reference book up to date. The 200-page table, "Physical Constants of Organic Compounds," has been revised to agree with rules of nomenclature laid down by the International Union of Chemistry. About 1,100 compounds have been added, making the total over 5,500. A table on "Formula Index of Organic Compounds" has been added, as well as a list of chemical words with their correct pronunciation. A number of other changes have also been made.

Diesel Standards

STANDARD PRACTICES (Dec., 1935)—*Published by the Diesel Engine Manufacturers' Assn., 2 West 45th St., New York, N. Y. Printed and distributed by Diesel Publications, Inc., 192 Lexington Ave., New York, N. Y. 162 pages. 6 x 9 in. Cloth. 29 diagrams. Price, $2.*

Published to define terms and practices in diesel plant purchase and installation. this volume succeeds the "Standards of the D.E.M.A.," published five years ago. Its work is to promote a more intelligent agreement between buyer, consultant and seller, particularly with regard to stationary plants using heavy-duty low and medium-speed engines of 200 hp. and above. It is primarily necessary background information for the diesel buyer or consultant more familiar with steam plants than with diesels.

New in this volume are a standard Field Test Code and a suggested form for specifications coordinated with suggestions on plant layout. The fifteen chapters include Standard Performances, Equipment and Definitions, Costs, Selection of Engine Sizes for a Given Load (abstracted in *Power*, Nov. 1935, pages 592-3). Buildings, Engine Construction, Governors, Speed Regulation, Erection, Fuel-Oil Storage and Handling Systems, Lubricating Oil Systems, Cooling Water Systems, Intake and Exhaust Systems, including Heat-Recovery Apparatus, Generators, Electrical Equipment, Torsional Vibration and Critical Speeds and the Specification and Code.

Power Chemistry

POWER PLANT CHEMISTRY (4th Ed.)—*By Augustus H. Gill, Professor-Emeritus, M.I.T. Published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N. Y. 221 pages, 5 x 8 in. Many tables and illustrations. Clothboard. Price, $2.50.*

The desire to cut the coal bill makes the ambitious power engineer something of a combustion and gas chemist. The desire to keep the plant running at all forces him to think about water analysis and treatment.

Professor Gill recognized a real demand years ago, when he brought out, in the first edition of this book, a simple outline of power-plant chemistry, particularly designed for those whose basic education along these lines had been somewhat neglected. Many who thought they knew a little about chemistry found Professor Gill's book useful as a review, and also as a summary of many facts not before brought to their attention.

Changes in the present edition include a more detailed treatment of fuels, particularly as regards storage and sampling of coal and specifications for diesels and other liquid fuels. The latest methods of carbon dioxide determination are described, and much new material on boiler scale, pitting and corrosion has been added by the author's colleague, Prof. Charles M. Wareham. Other additions include tests for mineral oil, specifications for lubricating oil, and various viscosity tests.

Brief Reviews

MAINTENANCE DEPARTMENT, THE (1935). *Report by Policyholders' Service Bureau, Metropolitan Life Insurance Co., 1 Madison Ave., New York, N. Y. Free.*—Organization, operation and control methods for the maintenance department.

SYMBOLS FOR METERING DIAGRAMS (1935). *Report by Electrical Equipment Committee of Edison Electric Institute. 420 Lexington Ave., New York, N. Y. 10 pages, 8½ x 11 in. Paper. Price, 10 cents.*

SEATTLE MUNICIPAL LIGHT & POWER SYSTEM (1935). *Published by the Municipal League of Seattle. Distributed by Willis F. Batcheller, Inc., 1903 Exchange Building, Seattle, Wash. 48 pages, 6 x 9 in. Paper. Many tables and charts. Price $1.*—Report on past record and future growth of Seattle system.

BOILER FURNACE DESIGN (1935). *By H. G. Lykken, Strong-Scott Mfg. Co., Minneapolis, Minn. 16 pages, 8½ x 11 in. Paper. Many illustrations and tables. No price given.*—Discussion of required energy absorption, dimensions and construction of furnaces.

Information for the Amateur Designer of Transformers for 25- to 60-cycle Circuits (1935). *By Herbert B. Brooks. Published by Bureau of Standards. Distributed by Superintendent of Documents, Washington, D. C. 25 pages, 6 x 9 in. Paper. 13 illustrations, including 6 graphs. Price, 5 cents.*—Complete information for design of 1- to 10-kw., 25- to 60-cycle transformers.

POWER EQUIPMENT FAILURES (1935). *Technical Report for 1933-34 by Royal Insurance Co., Ltd., 1 North John St., Liverpool, 2, England. 7¼ x 9¾ in. Paper. More than 160 illustrations, many charts and tables. Price, 7 shillings 6 pence.*—Voluminous report, detailed analyses of stresses and strains.

STANDARD DIESEL FUEL SPECIFICATIONS SOUGHT IN SURVEY OF MANUFACTURERS (1935). *By W. H. Hubner and G. B. Murphy. Published by Universal Oil Products Co., 310 S. Michigan Ave., Chicago, Ill. 14 pages, 6 x 9 in. Paper. 3 tables. Free*—Result of survey of 37 diesel manufacturers.

SMOKE & SOOT POLLUTION ANALYSIS (1935). *By Frank H. Lamping, supervisor, The Smoke Abatement League, Cincinnati, Ohio. 23 mimeograph pages, 8½ x 11 in. Paper. Many tables, diagrams. Free.*

RESULTS OF MUNICIPAL LIGHTING PLANTS (1935). *Published by Burns & McDonnell Engineering Co., 107 West Lindwood Blvd., Kansas City, Mo. 184 pages, 6 x 9 in. Paper. Price, $1.*—Rates, earnings, operating expenses, net profits, kw.-hr. production, etc., of 415 municipal plants.

MUNICIPAL SMOKE PROBLEM, THE (1935). *By H. B. Meller and L. B. Sisson. Published by Mellon Institute of Industrial Research Pittsburgh, Pa. 20 pages, 4 x 7 in. Paper. Free*—Primarily for the layman, this brief treatise describes causes and effects of smoke.

LEFAX (1935). *Data sheets for binders. Published by Lefax, Inc., Philadelphia, Pa.*—*"Interior Wiring" (6 pages) No. 14-94 and "Chemical Composition of S.A.E. Steels" (4 pages) No. 13-395.*

READERS' PROBLEMS

QUESTIONS for Our Readers

Patent or Capital First?

Question 1

ASSUMING *that an invention has reached the drawing board and been conditionally approved by competent engineers, what is the next step? Does the inventor wait for capital, perhaps indefinitely, or is it good business to submit it to anyone in its unprotected, undeveloped state? The logical procedure, of course, is to patent and develop one's creation. Lacking means to do this, is there no second choice?*—F.A.J.

Will Lime Purify Calcium Brine?

Question 2

WE HAVE *an ammonia-brine refrigerating system and the tank holds 2,500 gal. of brine. We had an ammonia leak in the brine tank and lost 200 lb. of ammonia. We ran off all the brine into the sewer and made fresh brine. We were told that we had wasted a lot of time and money as a few shovels of lime put into the tank would have neutralized the ammonia and purified the brine. Even though this were so, would it not wear out the pumps?*—J.S.B.

Suitable answers from readers will be paid for if space is available for publication.

REPLACING PISTON RINGS

ANSWERS TO DECEMBER QUESTION 1

The Question

WHEN *is it advisable to replace piston rings in diesels, gas engines, and compressors? I would like to have some sort of practical yardstick for measuring the proper interval between ring replacements.*—C.R.L.

Depends on Operation

PERHAPS the most common cause of wear is pressure leakage to the back of the rings, which greatly increases the tension of the rings on the cylinder liner. This fault also prevents formation of an oil film between the rings and the liner. Clearance of the ring in its groove should, therefore, be just sufficient to allow for expansion, say 0.003 in. up to 16 in. in diameter and 0.005 in. up to 25 in. in diameter. For the same reason, the split-end clearance should also be kept as small as possible; from 0.050 in. in 10-in. to 0.120 in. in 25-in. cylinders at the smallest bore diameter.

Naturally the rings nearest the pressure will have the greatest wear, thus may fail long before the others. From my experience with large marine diesels, rings should, under good operating conditions, remain in use about one year, and even then the lower rings may be cleaned and replaced. An operating rule of the ship was that a ring was renewed when end clearance had increased to three times the original.

Gas-engine rings give little trouble under good working conditions. When these rings wear unduly it may be that the air is dirty. This dirt, mixed with the lubricating oil, wears the rings and cylinder. Examination and cleaning once a year, with perhaps renewal of the two rings next the combustion space, is all that should be necessary.

The condition of compressor rings may be the difference between an efficient machine and one that is "cussed out" at frequent intervals. Close clearances and good but not liberal lubrication, with a supply of clean, dry air will reduce the ring wear almost to a minimum. Under normal operating conditions, renewal of the rings every year should be sufficient. Low-pressure stage rings should last indefinitely and require cleaning only at intervals. All rings should be renewed when end clearance increases to double the original. Even then they should be kept for use in an emergency.

Long Beach, Calif. A. G. ELLIOTT

Some General Pointers

NO DEFINITE rule can be established for replacing piston rings for diesels, gas engines or air compressors. Chief reasons are: difference in types of lubricating oils, variations in methods used to feed lubricants to the cylinder walls, tendency of different grades of fuels or lubricating oils to gum or carbonize, causing sticking rings and allowing hot gases to blow by and thus cut rings and cylinder walls; differences in maintenance practices; variations in materials.

However, it is usually possible for supervisors of individual machines to forecast replacements in ordinary repairs much before they are needed by routine inspection and records.

In gas engines, piston-ring replacement depends much on proper lubrication and cooling of cylinder walls and head, regular inspection, intelligent maintenance. Many mechanics renew rings without reboring or replacing the cylinder lining, consequently often get a non-satisfactory job. Manufacturers of most gas engines have a special pressure gage with an adapter to fit into a spark-plug opening. These gages are usually supplied at nominal cost and will indicate the loss of compression. Gas and gasoline engines, of course, have a greater tolerance in compression loss than a diesel.

Air compressors again offer a different problem due to the fact that they usually run slower than internal-combustion engines and have larger diameter pistons. When properly lubricated and cooled, maintenance is very low. However, they require frequent inspection to determine whether the piston is receiving enough oil and whether or not it is being properly distributed. An oil for a compressor should have a narrow range of distillation and relatively low viscosity so that it will break down cleanly instead of vaporizing in stages. Carbon produced should be light and fluffy instead of forming hard, gritty deposits. In a 2-stage compressor, an intercooler pressure above normal indicates that the piston rings or valves of a high-pressure cylinder are leaking. A subnormal intercooler pressure generally indicates that the valves or piston rings are leaking in a low-pressure cylinder.

Waynesboro, Va. J. M. MYERS

Routine Inspection and Record

ASH is the most detrimental remnant of the burning of fuel oil in diesels. It causes excessive wear of cylinders, rings and exhaust valves, and is usually composed of mineral particles of great hardness, which, becoming mixed with the lubricating oil, adhere to the piston and cylinder walls and cause excessive wear. An ash content in excess of 0.05% will render an otherwise excellent diesel oil unsuitable for use. Grit and dirt in intake air also cause wearing troubles.

Rings often gum badly, due either to too much lubricating oil or to imperfect combustion. The latter may be caused by overload, low air injection or low compression pressure. An engineer has to be a sort of mechanical doctor able to diagnose troubles from smell and sound. If the piston is badly worn, new rings will serve to hold the compression, but it is only a makeshift job. Some builders figure five new rings per cylinder every year. They suggest pulling the pistons after each 1,000 running hours. Many operating engineers spot curves and charts to keep a record of wear of all parts at each inspection. By so doing they are able to judge when new rings are needed.

Gas engines show many of the troubles found in diesels. "Blow by," caused by ring trouble and carbonization due to improper lubrication are outstanding among these. The remedy should be a regular inspection schedule of valves, pistons and rings, showing general condition and amount of wear.

Woodbury, N. J. R. W. CATER

Use a Notebook

THE only yardstick for ring replacement I have been able to work out in 13 years' experience is that of recording the amount of wear each time the pistons are taken out of the engines. Record ring width and depth in a notebook. From these readings you can see if the ring will stand until the next overhaul period or needs replacing.

I would rather throw away a ring that still had some wear left than to have one start leaking a short time after an overhauling, as the cost of pulling the piston will be more than the price of the new ring and the unit out of service. I have found this will happen just when you cannot shut down for

replacement and you are then operating the unit and getting poor fuel economy, also putting a lot of extra wear on the cylinder affected.

There cannot be a definite time interval, as no two rings in the same cylinder will show the same amount of wear.

I would advise C.R.L. to secure a caliper rule or 1-in. "mike" and a small notebook for this service. After a few overhauls he will know what to expect from each type of ring. He can compare the life of the same type of rings in different engines and soon select the type best suited for service on each.

Don't forget a leaking piston ring will cost more than a new ring in the loss of efficiency and extra labor.

Walthill, Neb. WM. W. DINGWALL

To Test Diesel-Ring Leakage

OWING to widely varying operating conditions, it is hard to establish the amount of permissible wear on piston rings for any class of service, be it for diesel, gas, compressor or steam engine. The one hard and fast rule is, that when a ring no longer holds the compression it is time to renew it. Fuel oil and gas comparatively free from mud and tarry substances, and air free from grit and abrasives or corrosive gases, must be used.

Installation of fuel-oil cleaning and heating apparatus and gas scrubbers will settle the dirty-fuel problem; as for clean air, use of any one of a number of reputable air filters on the market will solve this difficulty. You will find that close attention to these matters will lengthen the life of your rings greatly.

To test ring leakage in a diesel, jack the piston over to top center and turn air equal to maximum cylinder pressure into the cylinder. If the rings are leaky, the air can be heard "hissing" past the rings into the crankcase. Usually it is the uppermost rings that are at fault, as wear is always greatest at this point. If practical to do so, I would advise installation of a 2-piece ring in the two or three topmost grooves. Ring makers will advise the correct method of installing them. While they are a little higher in first cost, they are well worth the investment.

The same practice applies to gas engines of all types. Ring leakage will be evidenced by a hissing sound in the crankcase, and lubricating oil will be more or less contaminated with carbon in engine types where the crankcase is not closed off from the bottom of the cylinder. To check the amount of wear on any ring, compare with a new, unused ring. Ring leakage in a compressor will make itself known by a peculiar fluctuation of the pressure gages between stages, and a falling off of the final pressures for the same suction-valve setting.

If service is light, considerable wear is permissible, and if the service is severe, much less wear is tolerated.

Vero Beach, Fla. HOMER D. WHITE

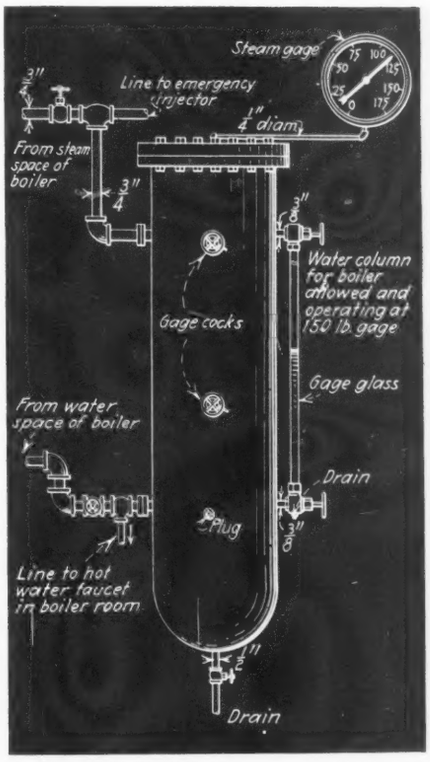
Use An Indicator

THERE is no set time to replace piston rings. The only safe way is to insure routine maintenance, proper lubrication, proper maintenance and then test periodically for leakage. The best way I have found for testing piston rings is to apply an engine indicator to the cylinder while in operation. If the piston rings are leaking only a little it will show on an indicator diagram. An increase in fuel consumption in a diesel or gas engine also indicates piston rings in bad shape.

Fort Wayne, Ind. JOHN L. WHITE

WHAT'S WRONG WITH THIS PICTURE?—I

COMMON WATER-COLUMN ERRORS



THERE are at least 16 mistakes shown in this drawing. Make a list of those you can recognize, then check against the list on the next page

FLOAT-GOVERNED FEEDWATER

ANSWERS to December Question 2

The Question

WE OPERATE *four boilers, and it has been suggested that we connect each boiler drum below the waterline to a 4-in. header and connect this header in turn to a standpipe or drum in which is arranged a float. Of course, a connection will also be made from this standpipe to the steam space of each boiler to equalize the pressure. The float will be used to control the throttle on our feed pump and so always maintain a proper water level. The suggestion does not seem good to me, but I should like to have* POWER *readers tell me what troubles will be likely to occur.*

—W.H.T.

Will Not Keep Level

I ASSUME the home-made feedwater regulator is to be operated for more than one of the four boilers. If this feedwater regulator was to control water level of a single boiler, it would be a satisfactory arrangement, providing its constructional details were correct. However, with two or more boilers having their water level controlled by a single regulator, trouble is certain to occur. For instance, let us assume that one boiler of the battery is being forced at a higher rating than the others. Evaporation will be greater and demand for feedwater will be greater. Neglecting unequal hydraulic friction drop in the individual boiler-feed lines, feedwater flow to boilers having a single regulator controlling the rate of feed-pump discharge will be equal. This equality of feedwater flow to any number of boilers will hold true regardless of individual variation in boiler-water levels.

Such a feedwater regulator would operate on the principle of an average water level for all boilers connected to it. Supposing the evaporation rate of boiler No. 1 was rather low, the rate of evaporation of boiler No. 2 was normal, and the output of boiler No. 3 higher than normal. The following condition would therefore exist: Boiler No. 2 would have its water level properly controlled. Boiler No. 1, operating at a low load, would be receiving feedwater at a rate proper for normal output, and its water level would go increasingly high. Boiler No. 3, operating at a high rating, would receive water only fast enough for normal rates, and its water level would go dangerously low.

Cleveland, Ohio M. E. WAGNER

Insurance Co. Won't Permit

THE proposed arrangement of operating four boilers on a 4-in. common water header in order to maintain a common water level by use of a float or feedwater regulator operated in a standpipe or drum at one end of the header will not prove satisfactory.

A battery of low-pressure or heating boilers may work in this manner if the water header is properly installed and of ample size and if the steam header is of large diameter so that there can be no difference in the steam pressure in the various boiler drums.

The reason that this arrangement will not work satisfactorily is that with the boilers working at various loads there will be slight differences in the steam pressure in each boiler, especially while operating at high rating. If for any reason steam flow is restricted from one of the boilers operating in this way until the steam pressure exceeds the other boiler by ½ lb. on the gage, it will force water level down in this particular boiler and up in the other boilers so that the difference in levels will be over 1 ft., depending on water temperature and gravity.

Corpus Christi, Texas. NELSON A. MINER

Water Feed Affected

THE question probably refers to low-pressure boilers operated at low rating. If this assumption is correct, the proposed scheme can only lead to trouble. If the boilers are medium

or high pressure operated at high ratings, the proposal is actually dangerous.

Water level in a boiler when steaming is always an artificial one. The actual volume of water in the drum would be below the level showing in the glass if no steaming occurred. This is due to minute bubbles of steam constantly rising through the water in sufficient number literally to raise the water level. Thus, any increase in steaming rate will cause a temporary rise in water level; and a decrease in steaming rate causes a temporary drop in water level. Proper level control must take care of this.

Obviously with the proposed scheme the rate of flow will not be governed by the steaming level of the water in the boilers. If the safety valve blows, or there is a sudden increase in steam load, water level will rise in the boiler or boilers, but since there is no steaming in the external float chamber, level there will remain in approximately the same position and water will be fed to the boiler at the same rate as when the steaming level was lower. The unpleasant results of water carry-over are too well known to be dwelt upon here.

Likewise, a sudden drop in steam load would drop the level in the boiler, while the level in the float chamber would not open the pump governor. If the delay were long enough, the level in the boiler would become dangerously low.

In addition, experience has shown that water level control in modern boilers at high ratings must be accomplished at the boiler. This is due primarily to the required sensitiveness of regulation because of physical dimensions of drums; and, in part, is necessary to remove the time lag when governing is done at the pump, either by throttling or control of pump speed.

A further objection is the question of balancing steam load between the four boilers. Temporary fluctuations in pressure and steaming rate are bound to occur in the boilers due to their positions on the steam header with respect to the point of demand. This variation would be reflected in the pressure connection to the float-chamber and would cause hunting and erratic operation of the pump governor. Corresponding fluctuations in the water level in the boilers would not be followed by the float in the float-chamber.

Bloomsbury, N. J. A. H. RICHARDS

Dontcha Do It

YOUR suggestor must undoubtedly have thought that you had a most unique battery of boilers. For this boiler feedwater arrangement to work you would have to have the following operating conditions in your boiler room:

At all times and under all conditions each boiler would have to get the same amount of air and coal and burn it at the same rate, so the boilers will have to have the same steaming rate. The steam header and boiler leads would have to be arranged so that there would be no tendency to bottle up any one boiler. Each pop-off valve would have to open at exactly the same point, all fires would have to be cleaned at the same time so as not to change the steaming rate of any one boiler.

With this hookup, if the steaming rate of any one boiler were to slow up, the other boilers will blow through the feedwater line and fill it full of water. To counteract these conditions, your suggestor would probably say to put check valves in the water lines to each boiler to prevent this exchange of water from boiler to boiler.

With check valves working, if any operating condition changes pressure in any boiler, the lower-pressured boiler would get more of the feedwater and the higher-pressured boiler less until some boiler or boilers would have a dangerously low water level.

So there are so many impossible conditions to maintain and no advantages it is very much to the point to say, "Dontcha do it."

Clarksville, Tenn. ZANZIE EDWARDS

WHAT'S WRONG WITH THIS PICTURE?—I

COMMON WATER COLUMN ERRORS—SEE PAGE 107

OUT of every hundred boiler installations, over twenty mistakes of the type shown in the sketch are found. Although some are of minor importance, others may cause serious results. Errors shown, possible operating difficulties, and corrective steps are:

1. *Steam gage calibration too low.* It is a regulation of the A.S.M.E. Boiler Code, and most states having a boiler code, that the steam gage shall not be calibrated to less than 1½ times maximum boiler working pressure. In case of a sticking safety valve, true pressure will then be indicated. Also, this stipulation prevents the gage mechanism from operating constantly at near its maximum.

2. *No syphon in steam-gage piping.* A syphon or water leg should be provided to prevent steam displacing water in the bourdon tube in the gage. Such an occurance overheats the tube and adjacent pinion-shaft spring, partially annealing them and destroying gage accuracy.

3. *No test connection.* A ¼-in. branch line should be taken off the pressure-gage piping and fitted with a ¼-in. threaded cock to permit attaching a test gage for determining steam gage accuracy.

4. *No shut-off cock.* A shut-off cock with a tee or lever handle arranged to be parallel to the pipe when the cock is open should be provided in the pressure-gage line close to the gage. This serves to shut the line off temporarily during a change of pressure gages.

5. *Lower gage cock missing.* It is important to provide gage cocks in all three connections of the water column. In case a gage glass breaks and difficulty is encountered in replacing it, gage cocks must be operated frequently to determine water level while gage-glass valves are shut off.

6. *Globe valve in water-column drain.* Use of a gate valve in this connection is preferred. It is compulsory in some states. A globe valve becomes obstructed too easily, and its seat cuts and scores quickly where used with dirty, scale-filled water. A globe valve may, however, be used outside the gate valve for tightness.

7. *Crosses instead of elbows.* Where practicable, water-column piping should have a cross at each right-angle turn to facilitate cleaning. Elbows or tees form a pocket for sludge and scale. When the boiler is down for cleaning the plugs may be removed from the crosses and the connections easily cleaned.

8. *Steam line from water-column connection.* No connection should be taken off from water-column piping other than connections for steam gage, drains, combustion-control equipment, damper regulators, feedwater regulators, or any similar equipment to which flow is negligible. Any appreciable flow through any such connection would cause a drop in pressure in the water-column connecting piping, with a corresponding change in water level in the column and glass. The reading thus indicated might be so far in error as to be dangerous.

9. *Hot-water line from water connection of water column.* No connection from the lower piping to the water column other than discussed in the above paragraph should be allowed for the same reasons.

10. *Shut-off valve in water column.* Quoting from the A.S.M.E. Power Boiler Code, P-293: "When shut-offs are used on the connections to a water column, they shall be either outside-screw-and-yoke type gate valves or stop cocks with levers permanently fastened thereto and marked in line with their passage, or of such other through-blow construction as to prevent stoppage by deposits of sediment, and to indicate by the position of the operating mechanism whether it is in open or closed position; and such valves or cocks shall be locked or sealed open. Where stop cocks are used they shall be of a type with the plug held in place by a guard or gland."

11. *Gage-glass connections too small.* The gage-glass connections to a boiler or water column should not be less than ½-in. pipe.

12. *Water-column connections too small.* A.S.M.E. Boiler Regulations state that the minimum size of pipes connecting the water column to a boiler shall be 1 in.

13. *No gage-glass guide rods.* Guide rods between gage-glass fittings should be provided to maintain correct alignment. A slight misalignment of gage-glass fittings often results in frequent exploding of glasses. Guide rods also protect the glass from being struck.

14. *Gage-glass drain plug.* The lower connection of the gage-glass should be provided with a drain valve or cock. A plugged connection is too frequently neglected. Filling up of this connection with sediment would cause water to show in the glass even though water level might be dangerously low.

15. *Water-column connection drains towards column.* A very dangerous procedure is to pipe the water column so that the lower connection drains towards the column. In case of falling water level in the boiler, the lower water-column connection will still hold water even after it has become uncovered in the boiler by low water. This connection should always drain towards the boiler.

16. *Water-column drain too small.* Water-column blow-off pipe should not be smaller than ¾ in. Use of a smaller pipe increases chances of obstruction by scale or sediment.

Brookline, Mass. HARRY M. SPRING

DIESELS GO TO SEA

Compression-ignition engines take over the Motor Boat Show —Four opposed-piston designs—Several new engine types

DIESELS, diesels, diesels—they were the byword of the Motor Boat Show in Grand Central Palace, New York, Jan. 17-25.

Particularly interesting among the new engines was the tendency toward opposed-piston designs. The Hill "Balanced" diesel, designed by R. E. Olds, is an opposed-piston, horizontal engine, with the crankshaft directly beneath the cylinder. Cylinder, water jacket, scavenging chamber, exhaust passage, crankcase and combustion chamber are cast integral, bolted-on covers closing the crankcase bottom and ends as in the photograph.

Each connecting rod, instead of passing directly to its crank, goes instead to a rocker arm, which in turn is connected by rod to the crank. Out-thrust on the rocker arms is taken by steel tension rods connecting the fulcrum bearings, and the rockers are slightly offset to align the rocker rods with their respective crank journals. Since balanced masses move in opposite directions simultaneously, the unit is balanced and very quiet. It contains 250 fewer parts than the conventional 4-cycle engine of equivalent horsepower. A piston can be pulled, rings changed, and piston returned in less than 5 min. The opposed-piston design cuts out valves, camshaft, pushrods, etc., as well as head gaskets. The scavenging blower is directly on the crankshaft at the front of the engine. The engine is two-cycle with inlet air ports uncovered by one piston, exhaust ports by the other, giving a "straight-through" flow.

One engine shown is a $2\frac{1}{2}$x$3\frac{1}{2}$-in. rated 10 hp. at 1,200 r.p.m., and 15 hp. at 1,800 r.p.m. The same unit is available for stationary service rated at 10 hp. at 1,200 r.p.m., or direct-connected to a 5-kw. generator. Height is exceptionally low, 22 in., by 25 in. wide and 24 in. long. The engine can be built with any even number of pistons, by lengthening the block.

Sterling Engine Co. again showed its crankless diesel, now modified for welded construction, and running at 1,200 r.p.m.

Fairbanks Morse had on exhibit its opposed-piston design, which has recently been sold to the Navy for submarine service. Upper and lower crankshafts are connected by chain, to avoid long connecting rods and 3-throw crankshafts, with their accompanying difficulties. The model shown has 5-in. bore by combined stroke of 12 in., and produces 300 hp. at 720 r.p.m. FM also showed a number of its standard engines.

An English diesel soon to be made in this country also utilizes the opposed-piston principle. The Covic is a cold-starting, 4-cycle, 15-18 hp. diesel having 3 9/64-in. bore and 3 15/16-in. stroke. Speed range is 500 to 3,500 r.p.m. Removable wet-type cylinder liners, roller bearings on crankshaft and connecting rods, separate fuel pumps. Weight is about 20 lb. per hp. without generator.

Red Wing showed a Hesselman type oil engine, which uses low compression and electric ignition. Injection valves and spark plugs point into a cup-shaped piston which is claimed to increase power and lessen spark-plug fouling. Fuel is regulated according to load and speed by a vacuum system, and cooling-water temperatures are thermostatically controlled.

Red Wing also showed a new Comet-type diesel built under Ricardo patents with the Comet combustion chamber, a spherical chamber in the cylinder head into which about 80% of the air is compressed before fuel is injected. Sizes from 75 to 120 hp. are available at speeds of 1,500 r.p.m.

Winton Engine Co. showed three engines, an 8-cyl., 500-hp., 1,000-r.p.m. unit of welded construction weighing 12,700 lb., and two 8-cyl., 200-hp., 1,400-r.p.m. units of cast construction weighing 4,500 lb. each. The latter are of new design, featuring a unit injection system with fuel pump and injection valve in one element in the cylinder head. This avoids high-pressure piping and gives more accurate metering.

Buda's new line of Silver Crown diesels all have the Lanova head, old in Europe, but thus far little heard of in this country. Buda's tests indicate that the head gives better combustion and cleaner exhaust than the older design, and with a compression ratio of only $12\frac{1}{2}$ to 1. Engines available in this type vary from 55 to 180 hp.

Bolinders showed again its standard diesels, varied this year in that weight per b.hp. has been cut to 33 lb. Bolinders uses its own injection system, with a separate cut-out for each cylinder. The cam which drives the fuel-injection pumps is geared to the shaft, just as is the variable-speed governor which allows the operator to control speed at will from about 100 r.p.m. up to 1,000.

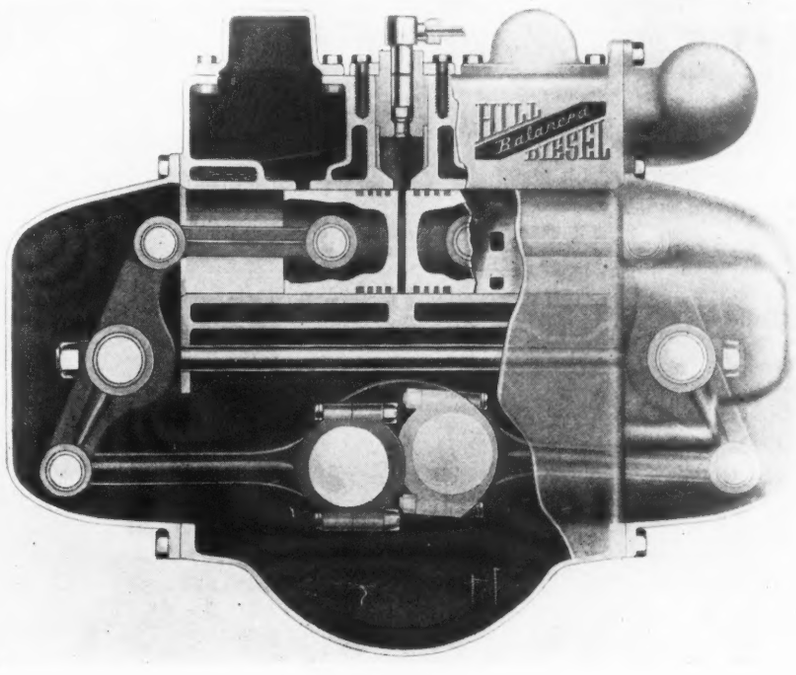
Cooper-Bessemer showed two recent additions to its N line, one a 6-cyl., $10\frac{1}{4}$x$13\frac{1}{2}$-in. developing 75 hp. per cylinder at 600 r.p.m. (this line includes 3, 4, 6, and 8-cyl. engines), and a 4-cyl., 8x10-in. unit developing 40 hp. per cyl. at 400 r.p.m. (also includes 3, 4, 6, and 8-cyl. units). All use through-bolt construction, cylinder liners bolted to cylinder heads, and a modification of the common-rail injection system which includes an atmospheric-relief arrangement to avoid dribble and noise.

Atlas-Imperial showed several engines featuring the new Atimco fuel systems, a modification of this company's common-rail system which avoids the delicate adjustments formerly necessary to equalize loading between cylinders. A metering valve fed from an accumulator delivers a measured amount of fuel to each cylinder in turn through a distributor. Since the same valve measures a standard quantity there cannot be variation in quantity of fuel fed, and beginning and end of fuel feed are claimed to be sharper. A fuel pump maintains accumulator pressure. Units have a dry-sump lubrication system, used oil flowing into a base sump. From this it is drawn by a pump into a sludge compartment, then is filtered, and a second pump pumps it back to the bearings.

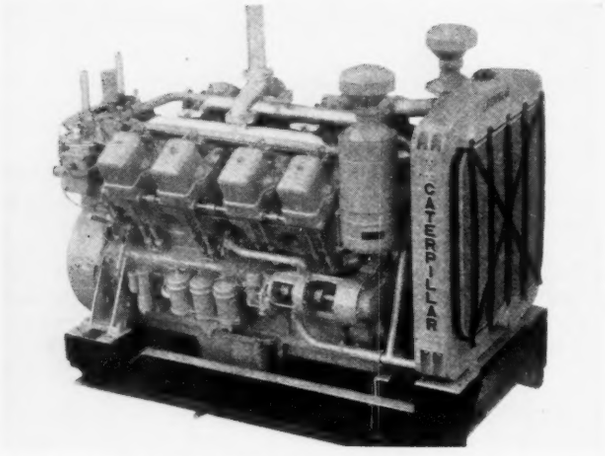
National Superior showed a new high-speed, 8-cyl., $4\frac{1}{2}$x$5\frac{3}{4}$-in. engine developing 150 hp. at 1,800 r.p.m. The largest boat at the Show, a 56-ft. Wheeler cruiser, was powered with two of these, one right-hand and one left. These engines can be 2, 4, 6, and 8 cyl., as generator units also. Superior also showed its 9x12-in., 600-r.p.m., a heavier, more rugged type.

Hall-Scott Motor Car Co. introduced its new 4-cycle, solid-injection diesel utilizing unit construction. There are four units: cylinder heads carrying the valve gear, cylinder block and upper crankcase with the liners, lower crankcase, and rocker-arm enclosure. Electric starting is used and the new Excello fuel pump. A compression release controlled by lever lessens the starting load.

Detail of Hill opposed-piston diesel rocker-arm arrangement



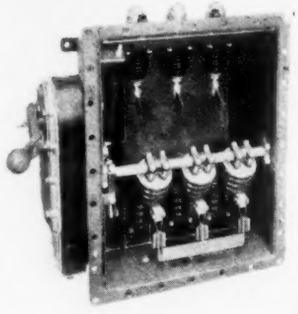
WHAT'S NEW IN PLANT EQUIPMENT



V-8, 160-HP. DIESEL UNIT

D17000, to be combined with an 80-kw. generator for smaller municipal plants and industrial use, or as a power unit for pumps, gins, flour mills, refrigerating plants and construction equipment, is a 4-cycle, valve-in-head, solid-injection diesel. Water-cooled, with integral radiator and fan. Bore 5¾ in., stroke 8 in., governed speed 850 r.p.m. Cylinders are in two groups of four, at 60 deg. Cylinder heads cast separately for ease of removal. Liners heat-treated chrome-nickel alloy cast iron. Cylinder blocks cast in pairs. Grey-iron crankcase, heavily ribbed, with 4 openings each side for access to bearings. Blocks may be raised off crankcase for examination of connecting-rod or crankpin bearings. 4-in., drop-forged crankshaft in 5 main bearings. Individual fuel pumps in one line at center of V, with even-length fuel lines. Fuel- and lubricating-oil filters, air cleaner, manifolding, cooling and thermostatic control individual for each bank. Force-feed lubrication. 28-hp., 2-cyl., horizontal, gasoline starting engine mounted at rear over flywheel, thus requiring no extra space. 4-cycle, opposed-piston design 3¾x4 in., running at governed speed of 3,000 r.p.m., and its circulating system ties in with that of diesel to speed starting. Diesel weight, fan to flywheel, is 7,150 lb.; weight of complete power unit with radiator and all accessories 11,500 lb.

Caterpillar Tractor Co., Peoria, Ill.



3-POSITION SWITCH UNIT

OIL-IMMERSED 7.5 kv., 3-position switch unit for mounting on or near transformer for sectionalizing from line in net-work or radial systems. Locked-off position for sectionalizing and cable grounding when men are working. Switch may be locked in all three positions by mechanical interlock, and electrical interlock prevents operation if line and transformer are alive.

Delta Star Electric Co., 2400 Block, Fulton St., Chicago, Ill.

MAGNETIC PIPE DETECTOR

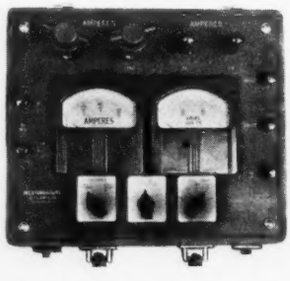
SURVEYING compass with adjustable bar magnet for reducing effect of earth's magnetic field is used in locating "missing" pipes. Fixed to compass box, and turning with it, two radial fins serve as magnetic antennae. Detector is sensitive to iron or steel pipe lines, having any magnetic bearing, and at considerable distance. Used with or without electric current through the pipe, although small current makes search easier and more certain. Non-magnetic pipes require an electric current. Will also determine depth of pipe.

General Electric Co., Schenectady, N. Y.

600-VOLT, 100-AMP. PLUGS AND RECEPTACLES

FOR extra heavy duty where conventional plugs and receptacles are not well suited, this "JUMBO-TYPE" has elements held in position by screwing together heavy metal outer sections. Receptacles are tapped for 2-in. conduit and for smaller sizes; reducing bushing is used. Two-, three- and four-pole combinations.

Delta Star Electric Co., Chicago, Ill.



D.C. INDUSTRIAL ANALYZER

ANALYZER in case 8 x 11 x 13 in., has ammeter with self-contained shunts for 7½, 75, 750 amp., which can be changed to 50-millivolt instrument by switch. Second instrument reads volts and ohms, has switch for changing ranges. Voltage ranges are 150, 300, and 750 volts. Ohm ranges are 5 and 500 at center of scale, can be read from 0.1 ohm to 20,000 ohms. Indicates amperes and volts at same time.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

SEAMLESS ALLOY TUBES

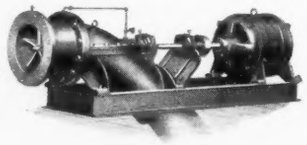
SEAMLESS tubes and pipe of alloy steel, called B.&W. Croloy 25-20, containing 25% chromium and 20% nickel, are hot-finished in sizes up to 6 in. O.D., and cold-drawn in smaller sizes. Has high degree of oxidation resistance for continuous operation at temperatures up to 2,100 deg.

Babcock & Wilcox Tube Co., Beaver Falls, Pa.

AXIAL FLOW PUMP

CLASS A, axial-flow pump for handling large volumes at low heads is extremely simple and can be direct-connected to an electric motor. Tube-shaped casing also acts as part of water passage. Propeller similar to marine type. 12-, 16- and 20-in. sizes.

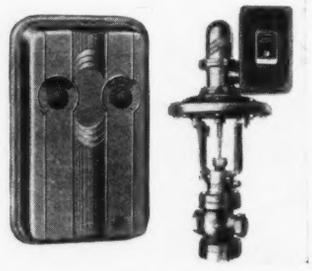
Pennsylvania Pump & Compressor Co., Easton, Pa.



COMBINED HUMIDISTAT AND THERMOSTAT

HYTHERSTAT combines internal mechanism of humidistat and thermostat in case 4½ in. x 7 in. x 1¾in., to control temperature and humidiy with air-conditioning systems. Comfortrol is same except dials are intergeared to give control in terms of effective temperature. Bulletin No. C.

Julien P. Friez & Sons Inc., Baltimore St. and Central Ave., Baltimore, Md.



VERNIER VALVE CONTROL

VERNIER VALVACTOR enables throttling type air-operated control instrument to make small gradual adjustments of control valve position, regardless of friction or hysteresis. Guarantees exact valve response where valve stem packing must be tight to prevent leakage. In cast aluminum case, available in gas-tight construction. Attached to spring housing of all sizes of "Stabilflo" valves or mounted on side of motor supports for needle valves

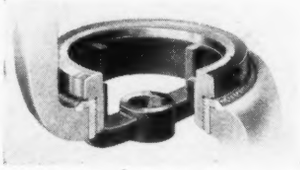
and valves without Stabilflo type of motor.

The Foxboro Co., Foxboro, Mass.

STATIC A.C. VOLTAGE REGULATOR

VOLTAGE regulator for small a.c. generators, has no moving parts. Current, proportional to load, compounds exciter field, varying with generator voltage. Energy obtained from generator potential through combination of reactor, resistor and dry type rectifier circuits. Initial size for units where exciter field current is 1 amp. or less.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



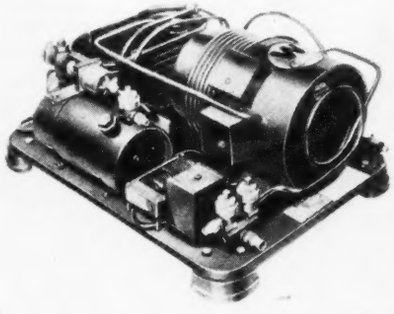
WELDED VALVE SEAT

SEPARATE ring of Seco metal, threaded to take seat ring, is welded into valve body to resist wire-drawing. Slight leak will not damage threads and, if necessary, seat ring can be taken out, cleaned, and jammed back tight. Bulletin No. 5.

Spence Engineering Co., Inc., 110 East 42nd St., New York.

CONDENSING UNIT

HERMETICALLY sealed commercial condensing unit. Type WFB-33H, uses water as condensing medium and Freon as refrigerant. Installed in closets, under counters, back of bars, etc. Unit



24 in. long, 18½ in. wide, 11⅜ in. high, can be built into cabinet without louvres. ⅓-hp. capacitor type motor direct-connected to 2-cyl., 1 x ⅞-in. compressor.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

CURRENT-INPUT CONTROLLERS

(Right)

FOR regulating current input to electrically-heated units, these controllers are made in four models. M to prevent temperature of constant load from rising above setting. MT same as M, but has time control. F for installations with slight lag, FL for greater lag in furnace response. Number may be used in series to control whole heating program. Turning knob adjusts switch in relation to rotating cam determining period of current flow during each cam rotation. Unit in aluminum case 8¼ x 9¾ x 4¾ in.

Automatic Temperature Control Co., Inc., 34 East Logan St., Philadelphia, Pa.

AIR-CONDITIONING UNIT

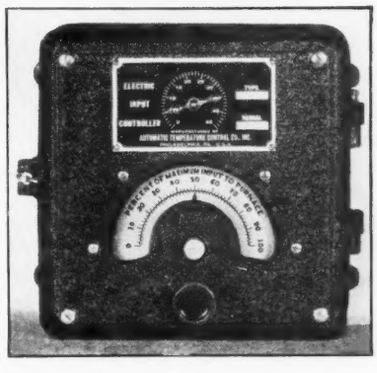
INDUSTRIAL air-conditioning units models FB-500, FB-800, FB-1400 and FB-2000 can be installed with or without distributing ducts. Automatic float control of refrigerant, ammonia, circulating brine or cold water. Unit inclosed in heavy steel casing with multi-blade, double-inlet fans, with V-belt drive. Automatic temperature control through thermostatic regulation, or by flow control.

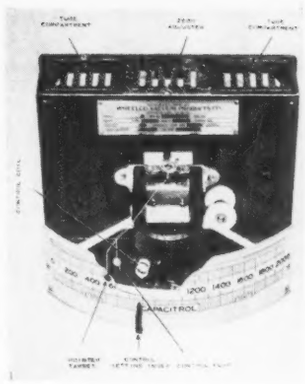
York Ice Machinery Corp., York, Pa.

COLD LINE PIPE INSULATION

ROCK cork pipe covering for cold lines is made of water-proofed rock wool. Waterproof jacket provides moisture resistance and seal against moisture-laden air. Fittings insulated with multiple layers of Zerotex waterproofed rock wool. Each layer sealed with double wrapping of waterproofed sealing tape, and completed with layer of asphalt base plastic.

Johns-Manville Corp., 22 East 40th St., New York, N. Y.





TEMPERATURE CONTROL

WHEELCO system has no electrical contacts. Tiny flag on pointer passes through field of coil in oscillator circuit affecting grid excitation of electron tube. Change in grid excitation causes rise or fall in plate current, which actuates mercury-tube relay. Coil on movable table set manually.

Thermo Control Devices, Inc., 1114 Milwaukee Ave., Chicago.

STROBOSCOPE

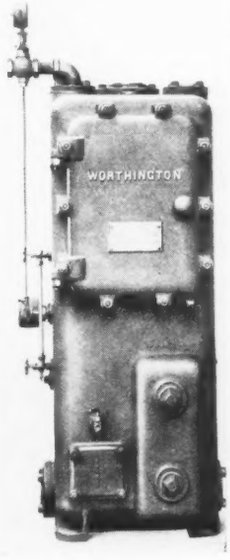
PORTABLE Stroboglow producing momentary illumination of 300,000 c.p. resulting in stroboscopic images with flash duration of about 10 microseconds. Inbuilt electronic timer. Mechanical contactor or high voltage used to trip lamp in Type PSE-2. 100 to 30,000 cycles per min.

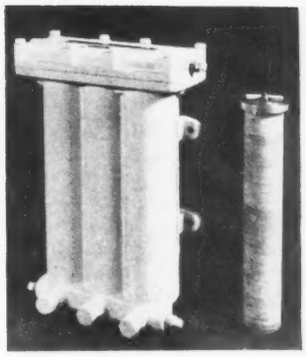
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

FEEDWATER HEATER

NON-DEAERATING, stationary feedwater heater uses exhaust steam to heat water within 2 deg. of saturation temperature. Multi-baffle separators to eliminate oil and two-pass filter to remove solid matter. Bulletin W-210-B19.

Worthington Pump & Machinery Corp., Harrison, N. J.





DIESEL FUEL FILTER

TYPE F-3 streamline filter uses filter element (shown at right of unit) composed of hundreds of special paper washers stacked on a central tube under compression. Fuel from transfer pump enters lower header, then passes into shell around paper washers. As it filters through quarter-millionth inch spaces between washers, any entrained dirt is deposited on outer surfaces. Cleaned oil passes up through central hole to upper header, thence to engine injector pump. Operation is continuous until dirt on surface retards capacity, then filter is flushed off by forcing a few ounces of oil back through between disks. Filter usually made up in nest of three packs, so that one may be cut out and flushed clean while others stay in service. Sludge drain plugs provided on bottom header; flushing pressure provided by pressure in discharge header. Gives high degree of purification; tests showed no wear on diesel injector pump after 115 million impulses. Cleaning required normally only at long intervals. Alternate cleaning arrangement when heavy fuels are filtered replaces back-pressure flow of filtered oil with a small pump and lighter, faster-flushing oil. Unit can be connected into present injector lines. Supporting lugs cast integral with shell, which is 6⅜ wide x 11¾ in. high by 2¼ in. thick.

Skinner Purifiers Inc., 2231 Dalzelle St., Detroit, Mich.

MULTI-V BELTS

Two styles of multi-V belts, one for small-pulley, short-center, high-speed drives is single-strand to withstand flexing and stretching. Other, for larger drives, has laminated construction with great number of cords and several layers of stiffening fabric.

B. F. Goodrich Co., Akron, Ohio.

POWER LINES

Westinghouse Celebrates Golden Jubilee

Westinghouse Electric & Mfg. Co. celebrated the beginning of its fiftieth anniversary year on Jan. 8 with an address by Chairman A. W. Robertson to 12,000 employees in Pittsburgh and 40,000 other employees throughout the world who heard the address over the company's own short-wave transmitter. Mr. Robertson reviewed the organization's past achievements and urged his listeners to carry on with the same constructive effort for the future.

DR. A. A. POTTER, Dean of Schools of Engineering, Purdue University, was elected president of American Engineering Council for 1936 and 1937 to succeed J. F. Coleman of New Orleans. Other officers elected at the 16th annual meeting Jan. 10-11 in Washington, D. C., were Ralph E. Flanders, president of the Jones & Lamson Machine Co., vice-president for two years, and J. S. Dodds, professor of civil engineering, Iowa State College, for one year. Other members of the executive committee and Frederick M. Feiker, executive secretary, were re-elected.

Coal and Embrittlement at A.I.M.E. Meeting

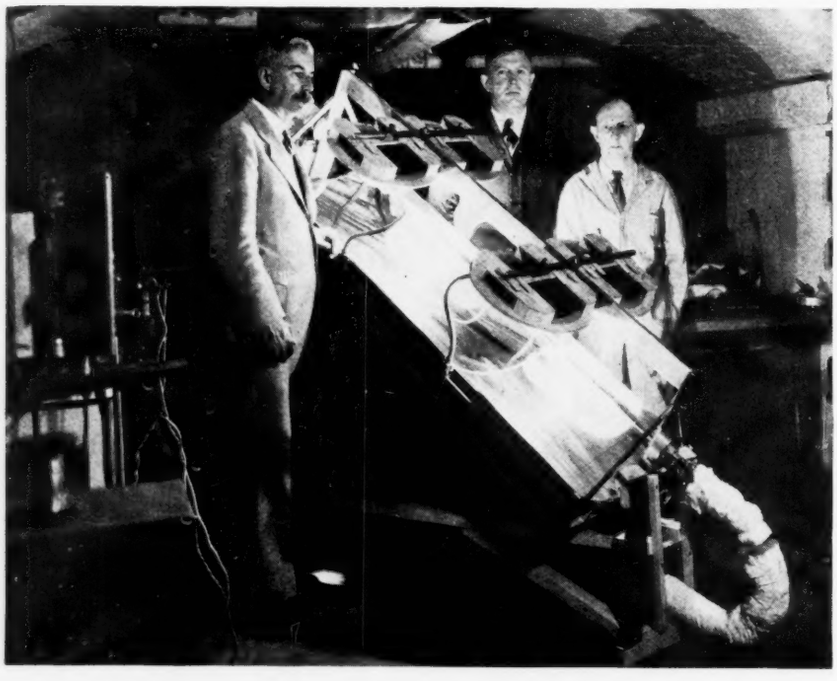
Caustic embrittlement will be discussed by W. C. Schroeder and A. A. Berk at the 145th meeting of A.I.M.E., Feb. 17 to 21, in the Engineering Societies Bldg., 29 West 39th St., New York, N. Y. Other papers included are: *Method for Estimating Grindability of Coal* by H. I. Yancey and M. R. Greer, *Effect of Volume vs. Weight on Grindability of Coal* by C. G. Black, *Concentration of Banded Ingredients of Illinois Coals by Screen Sizing and Washing* by Louis C. McCabe, *Bituminous Coal for Higher Temperature in Open-Hearth Furnaces* by Theodore Nagel, and *Statistical Analysis of Progress in Mechanical Cleaning of Bituminous Coal* by L. N. Plein. Discussion of papers presented at 1935 meetings on *Variables in Coal Sampling* and *Position of Illinois Coals* also.

Fuels at A.S.T.M. Meeting

Industrial fuels were discussed at a joint meeting of the A.S.T.M. and Philadelphia Engineers' Club which was held Tuesday, Jan. 21, at the Engineers' Club in Philadelphia. Program includes papers on: *Liquefied Gases* by W. H. Bateman, *Manufactured Gas* by W. H. Fulweiler, *Coal and Coke* by A. C. Fieldner and W. A. Selvig, and *Fuel Oil* by H. V. Hume.

ABBOT'S SOLAR HEATER

Dr. C. G. Abbot, secretary of the Smithsonian Institution, demonstrates his proposed unit for using the heat of the sun. A parabolic aluminum trough, highly polished, reflects 80% of the sun's rays through two concentric Pyrex tubes into a ¼-in. metal-packed Pyrex tube through which "Aroclor" liquid flows as a heat-transmitting medium. About 60 sq.ft. per hp. is required, over-all efficiency being 15%. Lamps and reflectors shown were used in St. Louis demonstration Dec. 30. Because of mirror shape, sun's rays can be kept working with only an occasional push; no complicated moving device



To Modernize Waterside

NEW YORK EDISON CO., INC., will spend about $5,000,000 to modernize its Waterside generating station, 40th St. and 1st Ave. 36 of the existing 146 boilers will be replaced by two 500,000 lb. per hr., 1,500 lb. pressure, 900 deg. units. New boilers will serve a new 50,000-kw., 60 cycle, turbo-generator, from which steam will exhaust at 200 lb. and pass through existing low pressure turbines to condenser. 450 ft. smokestack will also be erected.

Swain to Attend Leipzig Fair

Philip W. Swain, editor of *Power,* has announced his plans for an editorial trip to the Leipzig Trade Fair, Leipzig, Germany, to be followed by an engineering tour through Germany, Switzerland, France and England. Sailing Feb. 20 on the *Europa,* he plans to be back in New York early in April.

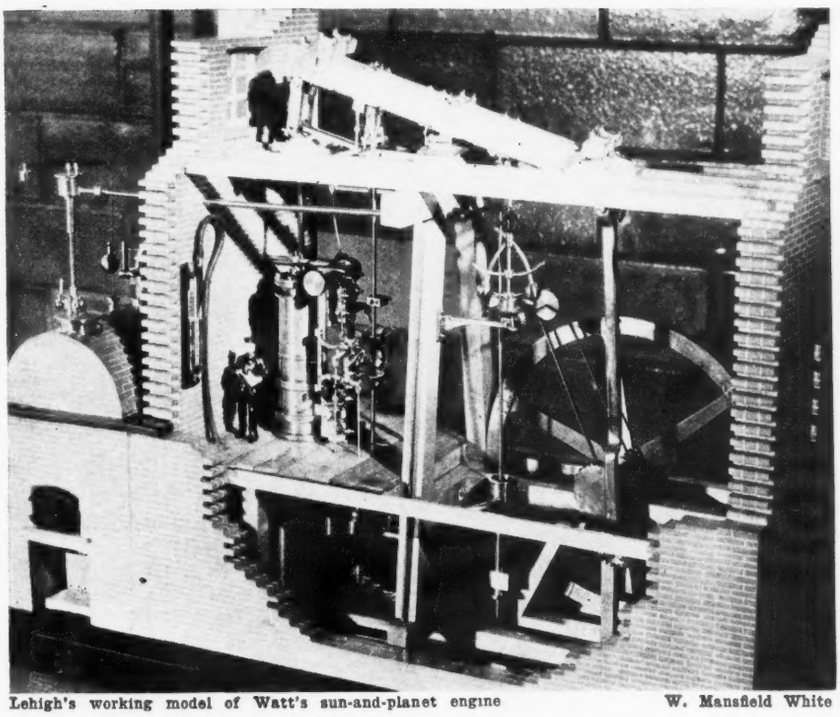
Arriving in Bremen Feb. 26, Mr. Swain will go directly to Berlin for a 2-day stay. During the Fair (March 1 to 9) he will remain in Leipzig studying the power and machinery exhibits. After the Fair he will spend several additional days in Berlin, visiting engineers, plants and factories of the neighborhood, and delivering a lecture on American power developments before the English-Speaking Circle of the Verein Deutscher Ingenieure. Thereafter he plans to visit Dresden, Munich, Nurumberg and several other German centers, noting particularly developments in boilers, diesel engines and prime movers. Swiss visits will include several large manufacturing plants near Baden, Zurich and Lucerne.

After a short stay in Paris, where he will meet a number of engineers, Mr. Swain will spend a week in England, largely in the vicinity of London. There he will study British developments in the power field, particularly advanced practice in stack-gas cleaning.

The Leipzig Fair is not only the largest periodic exhibition in the world. but also by far the oldest. Fairs have been held at Leipzig continuously for more than 700 years; the Spring Fair of 1936 will be the 1,975th. Approximately 8,000 firms will exhibit, of which 2,000 will show machinery, including power equipment, machine tools and textile machinery.

All-Glass Building

Owens-Illinois Glass Co.'s 2-story, glass-block, research laboratory, the world's first all-glass, windowless structure, was completed February 1. 80,000 glass blocks used to cover more than 20,000 sq.ft. are translucent but not transparent. Air-conditioning system provides 26,000 cu.ft. of conditioned air per minute. Return air enters grilles in glass block partitions at floor level, then is cleaned by passing through fibrous glass filters.



Lehigh's working model of Watt's sun-and-planet engine — W. Mansfield White

James Watt is Honored In England, Bethlehem and Philadelphia

IN A 3-day international program, starting Jan. 19, Bethlehem (Pa.) and Philadelphia joined hands with London in honoring James Watt, born in Greenock, Scotland, just 200 years before. In Philadelphia and elsewhere groups of engineers stayed up until the small hours of Sunday morning, January 19, to hear Watt's virtues broadcast over the Atlantic from the Science Museum at South Kensington, England. On Sunday afternoon they inspected large working replicas of Newcomen and Watt engines in Franklin Institute's palatial home in Philadelphia.

Monday the scene of activity shifted to the old Moravian town of Bethlehem, where Lehigh University staged addresses, exhibits, a luncheon and a dinner. It was fitting, many felt, that Lehigh, where Watt's statue (page 95) adorns the entrance to the great Packard laboratory, should join with institutions dedicated to Benjamin Franklin and Thomas Newcomen in honoring the man whose inventions made possible our present-day mechanical civilization.

Arthur M. Greene, Jr., dean of engineering at Princeton, presided at a Monday afternoon "Colloquium on James Watt." Speakers were Geo. A. Orrok, consulting engineer, New York, Joseph W. Roe, New York University professor, and Dexter S. Kimball, Dean of Engineering at Cornell. They spoke, respectively, of Watt, of his partner, Mathew Boulton, and of developments since Watt.

When James Watt was born in 1736, said Mr. Orrok, England's population was only 5½ million. Watt was a delicate child, diffident, but a natural student and mechanic.

At 20 he spent a year in London learning how to make philosophical instruments, then set up in this trade with the University in Glasgow for his board and room. Here he made instruments, experiments and durable friendships. This background, plus the chance to repair a Newcomen engine, led to Watt's greatest invention, the separate condenser.

Professor Roe stressed Boulton and showed that he in his way, was as great as Watt. Without Boulton's business genius and sympathetic understanding, Watt (lacking skill in business) might well have died obscure, penniless and utterly discouraged.

Mathew Boulton, said Professor Roe, had courage, judgment, vitality, generosity, ample capital. He was the one man in the world for Watt.

Dean Kimball's address dealt primarily with machines rather than with men. With lantern slides he traced the development of the steam engine from the days of James Watt to 1900. The original Watt engine, he said, used 10 lb. of coal per horsepower hour. Newcomen engine took about 40 lb. Following this session Prof. John Connelly of Lehigh demonstrated working models of the Newcomen and Watt engines.

The Lehigh exercises concluded with an evening session in which President Williams of Lehigh was made a member of the Newcomen Society. At the same meeting Wm. L. Batt, president of the A.S.M.E. spoke on "Watt—Symbol of the Industrial Age," and Wm. C. Dickerman, president of American Locomotive Company, on "Some Problems of a College President." C. E. Davies, A.S.M.E. secretary, extended to the officials and faculty of Lehigh the thanks and greetings of the Newcomen society (American branch) for their share in the celebration.

President Williams hoped that historians would come to understand that such men as Watt are more important than Napoleons and Bismarcks. Mr. Batt rated Watt as the greatest man in all recorded history and credited him directly or indirectly with the steam engine, the steamship, the locomotive, the industrial revolution, the modern machine tool, the automobile, mass production. The next twenty years may well be without precedent as were the past 20, Mr. Dickerman declared. Change is the only constant element in American life.

Tuesday afternoon the scene shifted back to the auditorium of the Franklin Institute in Philadelphia. Charles Penrose, vice-president for North America, presided for the Newcomen Society of England, following an inspection of the Institute's wonderful replicas of Watt and Newcomen engines.

Because of the King's death, Sir Gerald Campbell, British Consul General and honorary member of the Newcomen Society, could not be present. His address, read by Col. C. E. Davies, brought greetings from the Council of the Newcomen Society, London.

William Carter Dickerman, president, American Locomotive Co., inducted three new members: Dr. Thomas Jefferson Wertenbaker, Edwards Professor of American History at Princeton; James Alward Seymour, steam-engine pioneer; Samuel M. Vauclain, chairman of the board, Baldwin Locomotive Works. These three presented addresses. Mr. Vauclain showed "what steam has meant to us," outlining the life and works of James Watt, and their modern results, notably in the field of transportation.

Andrew Baxter, Jr., president of the St. Andrews Society of the State of New York, brought the greetings of a native Scotchman and praised the Scotch characteristics of Watt, emphasizing the human side. Mr. Penrose painted a vivid word picture of the American Colonies in 1736, when Watt was born.

Professor Wertenbaker gave the historian's view of "James Watt, inventor and pioneer."

Science, he declared, is on the threshold of so many and varied discoveries that the whole future will be revolutionized. But, he emphasized, we must study anew the economics of Adam Smith, as Watt studied them, if we are to handle this industrial age.

As an original partner of MacIntosh & Seymour, Mr. Seymour described "steam engines for an infant electric industry, 1885," confining his remarks to personal experiences with the engines big and small which made early utility history.

Engineers and celebrities crowded the ball room of the Bellevue Stratford at the formal dinner with which the Franklin Institute concluded the Watt celebration. Conrad N. Lauer, president of Philadelphia Gas Works and A.S.M.E. past president, was toastmaster. Colonel Davies read the eulogy of James Watt sent over by H. W. Dickinson of London. A cable of greeting from Scott's birthplace, Greenock, was read.

Julian P. Boyd, secretary of the Historical Society of Pennsylvania, spotlighted "Civilization Since James Watt." Steam alone, he said, has made it possible to concentrate populations and to build industrial capitalism. Geo. A. Orrok outlined the influence of Watt on the electric utility industry and Wm. C. Dickerman reviewed the spectacular achievements of the steam railroads.

NEWS NOTES

MANY papers of interest to plant engineers will be presented at the annual meeting of Technical Association of the Pulp and Paper Industry in New York the third week in February. Among these are: *The Characteristics of Power Requirements for Paper Machines* by H. W. Rogers; three papers on drying rates; *Heat Recovery in Alkaline Recovery Furnaces* by F. H. Rosencrants; *Diesel Engines as Applicable to the Paper Industry* by M. J. Reed; *Boiler Feedwater Treatment* by E. W. Butzler, and *Mechanical Design of Electrical Machinery* by C. H. Koch.

REVISED New York State Boiler Code containing numerous changes is now being distributed at $1 per copy from Bureau of Publications, Dept. of Labor, 80 Center St., New York, N. Y., or Room 905, State Office Bldg., Albany, N. Y.

HOBBIES have a measurable effect on efficiency according to studies made in plants represented at the Annual Hobby Show sponsored by the Foreman's Club, Toledo, Ohio. It was found that about 14% were closely related to the workers' crafts. Some hobbies revealed unknown talents. Most of the handicraft work entailed great attention to detail and precision which reflected in betted workmanship in the shop. The shows also have been found to give workers much greater pride in their work.

"CORNISH ENGINES PRESERVATION FUND" has been established to preserve at least one sample of the old beam engines used in the Cornish mines. Subscriptions may be sent to H. Michell, Manager of Barclays Bank, Falmouth Branch, England.

SOUTHERN INDUSTRIAL SHOW, which was to be held in Greenville, S. C., April 6 to 11 (*Power*—December, 1935) has been indefinitely postponed.

NATIONAL BUREAU OF STANDARDS, Division of Simplified Practice, announced that Simplified Practice Recommendation R57-32, on wrought-iron and wrought-steel pipe, valves and fittings, has been reaffirmed by the standing committee of the industry. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents each.

NEW TENTATIVE STANDARD for Wrought-Iron and Wrought-Steel Pipe was approved by American Standards Association, based on the formula developed for guidance in setting up theoretical wall thicknesses for a wide range of pressure-stress ratios. Copies available from A.S.M.E., 29 West 39th St., New York, N. Y., at 50 cents each.

German Diesel Industry Hit by High Oil Tariff

The German diesel engine industry is facing a serious problem. Almost overnight, and without consulting any of the interests concerned, the German government has raised by 100% the import duties on gas oil (diesel oil).

From the tariff viewpoint, the diesel motor heretofore occupied a privileged position in Germany. The import duty on diesel oil—4 marks per 100 kilograms—was only one-fourth that on gasoline. Consequently, the price relation between gas oil and gasoline was 1.3 in Germany as against 2.3 in most other countries where there were no import duties or where tariff rates for both kinds of motor fuel were approximately equal. This added to the advantage of more economic operation which the diesel motor possesses against the gasoline motor. The tariff increase is from 4 to 8 marks per 100 kilograms which automatically raised German gas oil prices by 20 to 25%.

The main motive in raising the tariff rate on gas oil was to encourage domestic oil production. Of all gasoline consumed in Germany 25% comes from domestic sources while in the case of gas oil this percentage is only 15%. The development of domestic resources of motor fuel is naturally considered of particular importance for raising Germany's self-sufficiency in case of war. On the other hand, it has been openly admitted that it is desirable to check the "triumphal advance" of the diesel motor in Germany which also from the military viewpoint is considered undesirable. Preference should be given to steam and electricity as power generators since they are independent of foreign fuel supplies in war time.

Germany still does not possess (or, at least, does not publish, any complete statistics of diesel motor production. The old Diesel Motor Association comprised 12 principal builders of diesel engines producing about 80% of total output. It did not, however, embrace automobile manufacturers making their own diesel engines. But in a recent issue the *Frankfurter Zeitung* published the following interesting figures of diesel engine *sales* (in HP) in the years 1928 to 1934.

German Sales of Diesel Engines

	Domestic 1,000 Hp.	Foreign 1,000 Hp.
1928	138.2	248.0
1929	148.7	366.1
1930	129.1	385.1
1931	118.0	218.4
1932	94.2	131.7
1933	284.4	228.5
1934	486.7	280.7

Sales figures for the last three years are highly characteristic of the main trends of German industrial recovery. While exports of diesel engines increased by 115%, domestic sales registered an increase by 410%. In 1935 this tendency was probably maintained, inland sales showing greater gains than exports. Nevertheless, the competitive position of the German diesel in world markets will to a large extent depend on the capacity of the domestic market. The greater the latter, the smaller is the overhead and the greater the possibilities of introducing technical and other improvements in current production.

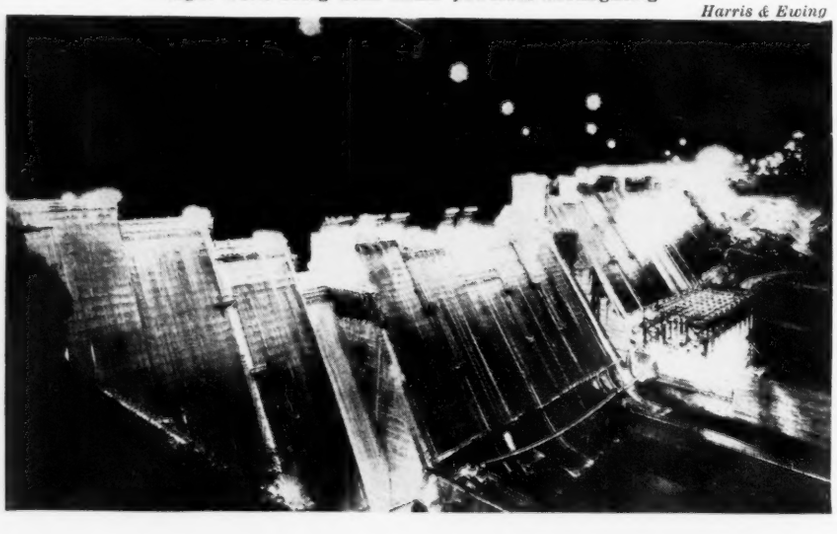
German diesel engine makers are, therefore, carefully appraising the possible effects of the doubled gas oil import duties and of higher domestic prices on the use of diesel engines in Germany. It is the consensus of opinion that the effect on engines for motor vehicles will be almost nil as the margin of profitable operation which has led to an almost complete elimination of the gasoline engine for trucks is so considerable, that the oil price increase has only insignificantly changed their present relative competitive position. Doubts are expressed, however, whether this measure may not retard the introduction of diesel engines for smaller vehicles.

The outlook in regard to stationary diesel engines is much more gloomy. Diesel-operated electric plants have already a very severe stand against electricity generated by steam and water-power. The narrow margin they still possessed with the lower import duty may now be altogether wiped out. As regards new installations it is reliably reported that orders for stationary diesel engines have been cancelled with several manufacturers. As to existing plants, the cost of operating a diesel has been increased by 20 to 25%, and it is probable that manufacturers will endeavor to shift to some other generator of power. This may, of course, have unfavorable repercussions on the production of diesel engines in Germany, and, indirectly, on export sales. It is therefore only natural when diesel engine makers point out that while the Government may save a small amount of the precious "Valuta" by reducing imports of gas oil, it is at the same time jeopardizing export trade in diesels which in 1935 yielded approximately 20 million marks in foreign exchange.

DAM WELL LIGHTED

Norris Dam, TVA project in Tennessee, is going up by leaps and bounds, night work being done under powerful floodlighting

Harris & Ewing



PERSONALS

L. E. GRIFFITH has been appointed vice-president and general manager of Riley Stoker Co., Worcester, Mass. After graduating from Lafayette University in 1912, Mr. Griffith became construction engineer with Thompson Starrett Co., superintendent of Central Metal Products Co., construction engineer of Pittsburgh Seamless Tube Co., and production engineer of Babcock & Wilcox Co., at Barberton, Ohio. When Riley Stoker Corp. purchased United Machine & Manufacturing Co., Mr. Griffith became manager of the New York office of Riley Stoker Co.

ROBERT H. WILD, formerly with Foster Wheeler Corp., has joined staff of Burns & Roe, Inc., 233 Broadway, New York, N. Y.

HENRY ROGERS, former steam-plant engineer for Boston & Maine Railroad, has been appointed chief engineer of Whidden Memorial Hospital, Everett, Mass., succeeding the late John E. Schriber.

A. S. HELLSTROM has been appointed manager of the Cleveland, Youngstown, Akron and Wheeling Districts, with offices in the Caxton Bldg., Cleveland, for Torrington Co., and its subsidiary, Bantam Ball Bearing Co.

CLARENCE E. SPAYD, consultant on safety engineering of Brooklyn Edison Co., was selected by Governor Lehman to represent New York State at the Accident Prevention Conference in Washington, D. C., Dec. 18.

DANIEL WEBSTER MEAD, nationally known hydraulic, power and valuation engineer of Madison, Wis., has been elected president of the American Society of Civil Engineers at the 83rd Annual Meeting at the Engineering Societies Bldg., 29 West 39h St., New York, N. Y., Jan. 15.

THOMAS N. ARMSTRONG, JR., former associate metallurgist at Norfolk Navy Yard, Portsmouth, Va., has been added to the technical staff of International Nickel Co., Inc., New York, N. Y.

R. L. MEAD has been appointed manager of the Chicago office of Harnischfeger Corp., at 20 North Wacker Drive.

JAMES W. ARMOUR, vice-president and chief engineer of Riley Stoker Co., Worcester, Mass., has been made manager of the Detroit office, while OLLISON CRAIG has been appointed manager of the engineering department. ARTHUR T. HUNTER has been named sales manager of the company. He was a sales representative in the power-plant field in St. Louis, Mo., before joining the Riley staff.

LLOYD D. LEAVER, former vice-president of mechanical rubber goods division, Thermoid Rubber Co., has joined the staff of Hamilton Rubber Mfg. Co., Trenton, N. J.

J. E. N. HUME, assistant manager of General Electric Co.'s industrial department, has been appointed manager, succeeding the late W. W. Miller.

WILLIAM C. DAVIS, formerly of United States Gypsum Co., has been appointed director of merchandising for industrial materials and structural materials division of Owens-Illinois Glass Co., Toledo, Ohio.

BUSINESS NOTES

REPUBLIC STEEL CORP. moved its general offices from Youngstown, Ohio, to Cleveland, Ohio, on Jan. 25. Offices will occupy floors 13 to 16 in the Republic Bldg. This consolidates the general, executive, Cleveland district sales offices and the advertising department. Sales offices of Newton Steel Co. will also be located in the building. Sales offices of Republic Alloy Steel Division will remain in Massillon, Ohio.

LADD EQUIPMENT CO., First National Bank Bldg., Pittsburgh, Pa., sales agents for Poole Foundry & Machine Co., Woodberry, Baltimore, Md., have added the state of Ohio with the exception of the immediate Cincinnati district to their territory. District office will be maintained in Rockefeller Bldg., Cleveland, Ohio, under G. H. Bales.

BURNS & ROE, INC., engineering consultants, 233 Broadway, New York, N. Y., have moved their offices to the Woolworth Bldg.

SHEFFLER-GROSS CO., INC., Drexel Bldg., Philadelphia, Pa., has taken on the account of Julien P. Friez & Sons, Inc., Baltimore, Md.

MARKHAM SUPPLY CO., 310 South Michigan Ave., Chicago, Ill., has been appointed agent for Babcock & Wilcox Tube Co., Beaver Falls, Pa.

S. A. RHODES, 2015 Main St., Cromwell, Conn., has been appointed Connecticut representative for Allen-Bradley Co., Milwaukee, Wis.

BARTLETT HAYWARD CO., Baltimore, Md., has made the following changes in personnel: Chester F. Hockley, former president since 1931, retired to become president of newly reorganized Davison Chemical Corp., but will continue as a director of Bartlett Hayward Co. Walter F. Perkins, former vice-president and general manager, was elected president. George E. Probest, Jr., former secretary and treasurer, was elected vice-president and treasurer. Herman H. Vordemberge, former assistant secretary and assistant treasurer, was elected secretary and assistant treasurer.

ALLEN-BRADLEY CO., Milwaukee, Wis., has moved its Grand Rapids, Mich., sales office to 410 Houseman Bldg.

APPALACHIAN COALS, INC., Transportation Bldg., Cincinnati, Ohio, though deprived of its pricing functions until the United States Supreme Court rules on the Guffey Act, will maintain an organization for service along other lines through funds contributed by stockholders.

PARKER APPLIANCE CO. has moved to a new plant at 17325 Euclid Ave., Cleveland, Ohio.

CONSULTING ENGINEERING CO., 1 Terminal Office Bldg., Carson St., Pittsburgh, Pa., has been appointed representative for Pennsylvania Pump & Compressor Co.

BAKELITE CORP., Bound Brook, N. J., and BLACK & DECKER MFG. CO., Towson, Md., have become members of the Exhibitors Advisory Council, Inc., New York, N. Y.

HENDRIE & BOLTHOFF MFG. & SUPPLY CO., 1635 Seventeenth St., Denver, Colo., have been appointed representative for Union Iron Works, Erie, Pa., in Colorado, Wyoming, western South Dakota, Nebraska and northern New Mexico.

OBITUARIES

HARRY LEVAN HORNING, 55, founder and treasurer of Waukesha Motor Co., Waukesha, Wis., died Jan. 4. Mr. Horning organized the Waukesha Motor Co., and became its chief engineer and general manager in 1906. He served as chairman of the Automotive Section of the War Industries Board, and in 1925 became president of the S.A.E.

ESKIL BERG, prominent retired engineer of General Electric Co., Schenectady, N. Y., and one-time associate of the late Dr. Charles P. Steinmetz, died Jan. 5. After graduating from Chalmers Institute of Technology in Sweden,

he came to this country and became associated with G.E. After Dr. Steinmetz' office had been discontinued, Mr. Berg became an associate of W. L. R. Emmet and was connected with work on the steam turbine and the development of the mercury turbine.

J. G. OBERMIER, 67, vice-president in charge of production and member of board of Timken Roller Bearing Co., died Dec. 28.

GEORGE EDSON SHEPARD, 62, treasurer of H. B. Smith Co., Westfield, Mass., died Jan. 12.

STRAWS

Pointing the way business winds blow

East

HAMMERMILL PAPER CO., Erie, Pa., has contracted with Stone & Webster Engineering Corp., for an extension to their No. 2 power plant. Work includes extension to boiler house and installation of two high-pressure boilers, each with capacity of 80,000 lb. per hr. at 650 lb. pressure, installation of 5,000-kw. turbine generator in the present turbine room, and steam line to connect turbine exhaust with steam distribution center in mill about 700 ft. away.

WORCESTER, MASS., City Hospital, has contracted for boilers and other equipment for power house with J. G. Lamotte & Sons, Inc., 54 Commercial St., Worcester. Expansion will cost about $57,000. Edward J. Tucker, City Hospital, engineer.

AMERICAN WRITING PAPER CO., INC., Holyoke, Mass., plans water turbine and auxiliary equipment in Nonotuck Division Mill. $45,000 being arranged for this and other work at plant. Will also make improvements to cost about $90,000 in plant at Planter and Porter-Parsons Division Mill.

SARANAC LAKE, N. Y., expects to begin work in spring on electric plant, including distribution lines. Estimates of cost being made. Burns & McDonnell Engineering Co., 107 West Linwood Blvd., Kansas City, Mo., consulting engineer.

CONTINENTAL CAN CO., 1 Pershing Square, New York, N. Y., plans steam plant for multi-unit plant on 15-acre tract recently acquired in Toronto, Ont. Will cost $550,000.

HOLYOKE (MASS.) WATER POWER CO. has ordered 200,000-lb. per hr. boiler from Riley Stoker Corp. as initial step in steam plant expansion program developed with assistance of Arthur L. Nelson Engineers, Boston, Mass. Provision for high-pressure 5,000-kw. turbo-generator and 12,500-kw. low-pressure turbo-generator has been made. Boiler designed for 750 lb. pressure with steam temperature of 750 deg. Furnace will burn fuel oil or pulverized coal.

South

GOVERNMENT construction of a hydro-electric plant at Great Falls on the Potomac River, just above Washington, has been proposed by representive Rankin of Mississippi, to supply power to the national capital and nearby sections of Virginia and Maryland.

EASTERN SHORE GAS CO., Salisbury, Md., plans improvements in artificial gas plant at Ocean City, Md., including additional equipment and extensions in pipe lines.

VIRGINIA ELECTRIC POWER CO. officials say it will be several weeks before construction will begin on $2,000,000 addition to Twelfth St. Station. Corps of engineers from Stone & Webster Engineering Co. is making preliminary surveys. Addition expected to be completed in the fall.

SMITH MOUNTAIN POWER CO., Alexandria, Va., has applied to Federal Power Commission for license covering 30,000-hp. project on Roanoke River at Smith Mountain. Plan to build 165-ft. concrete arch dam. Application has also been made for state rights. President of company is W. G. Waldo, Washington, D. C., R. L. Jenkins, Statesville, N. C., is vice-president. Development will include 30,000-hp. generator, dam 165 ft. high, 450 ft. wide at base, and 100 ft. at top, which will create a 9,800 acre lake with maximum head of 155 ft.

DUKE POWER CO., Charlotte, N. C., plans improvements in artificial gas plant on Main St., Burlington, N. C., with installation of equipment to double present capacity. Cost about $35,000. C. E. Scott, local manager.

SOUTH CAROLINA PUBLIC SERVICE AUTHORITY for Santee-Cooper project, Burnet R. Maybank, mayor, Columbia, S. C., chairman, has secured additional Federal loan of $5,500,000 for proposed hydro-electric and navigation development, making total loan of $6,000,000, and $5,500,000 grant available for project. Plans include hydro-electric station with eight 25,000-kva. units. 575 miles of transmission lines will be constructed. Parsons, Klapp, Brinckerhoff & Douglas, 142 Maiden Lane, New York, N. Y., consulting engineers.

FORT PIERCE (FLA.) GROWERS' ASSOCIATION, affiliated with Florida Citrus Exchange, Jacksonville, Fla., plans one-story steam plant for fruit packing plant on waterfront, where site has been secured. Project will cost close to $100,000.

EVERGLADES HAMPERS, INC., Belle Glade, Fla., M. M. Starling, president, plans boiler plant for veneer mill on 10-acre tract on Callahan-Yulee Highway, near Callahan, Fla. Plant will comprise four units. Work to begin soon. Cost close to $65,000.

MIAMI, FLA., plans pre-cooling plant for citrus fruit service in connection with warehouse to be constructed on waterfront at Pier No. 3. Cost about $50,000. Financing through Federal aid. William Sydow, director, Department of Public Service, in charge.

SAVANNAH RIVER hydro-electric project planned by Federal Government at Clark's Hill, about 21 miles from Augusta, Ga., is being investigated by commission, composed of Col. Earl I. Brown, Army Engineer; Roger B. McWhorter, chief engineer, Federal Power Commission; and Sherman M. Woodward, National Resources Committee, all of Washington, D. C. Project provides for construction of 100 ft. concrete-gravity dam, creating reservoir about 52 sq. miles, generating station, transmission and distribution lines, etc. Georgia Power Co., Atlanta, is cooperating with commission. Development estimated to cost $17,500,000.

BIRMINGHAM, ALA., plans development of water supply system for industrial service to cost about $6,000,000. Source located on Blackburn branch of Black Warrior River, vicinity of Oneonta, where electric pumping station and reservoir will be built. Secondary reservoir and pumping plant will be near city. Financing through Federal aid. Work to begin in March. A. Clinton Decker and O. G. Thurlow, Birmingham, consulting engineers; J. D. Webb, city engineer.

HOME ICE CO., Crowley, La., plans one-story ice plant, estimated to cost close to $30,000, with equipment. J. W. Barnett is head.

ARKANSAS-LOUISIANA GAS CO., Ardus Bldg., Shreveport, La., is considering construction of 8-in. welded-steel pipe-line from Rodessa, La., oil and gas field district to Caddo, La., and vicinity, about 15 miles. Cost over $150,000.

TVA, Knoxville, Tenn., has authorized construction of dam at Chickamauga Island on Tennessee River, 7 miles above Chattanooga, Tenn., to be 104 ft. high and 5685 ft. long, to create a reservoir about 65 sq. miles in area. At later date, hydro-electric station will be constructed with initial installation of six generating units of 160,000-kw. gross rating. Transmission lines will be built to connect with other TVA lines. Project will cost about $32,000,000. L. G. Warren, construction engineer, E. M. Whipple, construction superintendent.

Midwest

WEST SALEM EQUITY CO., West Salem, Ohio, plans rebuilding of boiler and engine plant of grain elevator unit, following recent fire. Loss estimated at $45,000.

BLUFFTON, IND., has awarded contracts for improvements in municipal plant, including boiler units to Bass Foundry & Machine Co., Fort Wayne, Ind., and stoker to Chicago Automatic Stoker Co., Chicago, Ill.

CARTHAGE, MO., has contracted Nordberg Mfg. Co., Milwaukee, Wis., for a 2,250-hp. diesel for municipal lighting plant. Contract is record order for company for size. Estimated to weigh 450,000 lbs., engine will require about five months to build.

MEXICO REFRACTORIES CO., Mexico, Mo., has constructed a second unit doubling its original capacity for the manufacture of refractories.

GRAND RAPIDS (MICH.) GAS LIGHT CO. plans 10¾-in. welded-steel pipe-line for natural gas supply for city, extending from Belvidere in Mecosta-Montcalm, Mich., gas field district to city limits, about 60 miles. Plant will be built at terminus for mixing natural and artificial gas for distribution. Entire project will cost about $850,000. Application for permission has been made.

LANSING, MICH., is planning municipal natural gas system, including main welded-steel pipe-line from Montcalm-Mecosta Counties gas field district to city, and distributing and meter station at city limits.

CHEVROLET MOTOR CO., Detroit, Mich., plans addition to power plant on East Euclid Ave., including improvements in present station. Cost over $80,000. Albert Kahn, Inc., New Center Bldg., architect and engineer.

PUBLIC LIGHTING COMMISSION, Detroit, Mich., plans improvements in municipal electric plant, including additional equipment for which fund of $580,000 has been authorized.

IRON COUNTY BOARD OF SUPERVISORS,

Iron River, Mich., has approved plans for steam heating plant at county jail, Crystal Falls, Mich. $37,000 arranged for this and other work.

POSTUM CO., INC., Battle Creek, Mich., has contracted with Stone & Webster Engineering Co. to construct power plant extension, including 100,000-lb. per hr. boiler at 700 lb. pressure and auxiliary equipment. Also a 2,500-kw. non-condensing extraction-type turbine generator. To cost about $125,000.

SCHLITZ BREWING CO., Milwaukee, Wis., plans extensions in power station and refrigerating plant at brewing plant at Davenport, Iowa. Six-story addition will be built. To cost over $850,000.

OGDEN, IOWA, has contracted Cooper-Bessemer Co., Grove City, Pa., for engine and auxiliary equipment for municipal power plant and Electric Engineering & Construction Co., Des Moines, Iowa, for switchboard and accessories. Orders for other equipment soon. Plant to cost close to $91,000.

HOPKINTON, IOWA, has secured low bid from A. A. Electric Co., Cicero, Ill., for equipment for municipal plant, including two diesel engines and accessories, switchboard, fuel oil tank and miscellaneous equipment, at $63,607. A. S. Harrington, Baum Bldg., Omaha, Neb., consulting engineer.

ELDON, IOWA, has contracted Fairbanks, Morse & Co., Chicago, Ill., for equipment for municipal diesel-electric plant, at $42,778. Work to begin soon. Young & Stanley, Muscatine, Iowa, consulting engineers.

SANBORN, IOWA, has bonds for $90,000 for municipal electric plant, and will arrange Federal financing.

METROPOLITAN UTILITIES DISTRICT, Omaha, Neb., plans improvements in municipal waterworks, with installation of pumping units and auxiliary equipment. Cost about $35,000. Financing through Federal aid.

BUREAU OF RECLAMATION, Denver, Colo., has contracted S. J. Groves & Sons Co., Minneapolis, Minn., for construction of dam and hydro-electric development for irrigation project near Riverton, Wyo., at cost of $653,397. Dam at Bull Lake scheduled for completion before 1938.

BUREAU OF RECLAMATION, Denver, Colo., has contracted Winston Brothers Co., Minneapolis, Minn., Utah Construction Co., Ogden, Utah, and Morrison-Knudsen Co., Boise, Idaho, for construction of Seminoe dam and power plant near Casper, Wyo., forming part of Casper-Alcova Project, at $2,759,804. Bids for power plant equipment, transmission lines and other work later.

West

WASHINGTON, KAN., takes bids soon for municipal diesel-electric plant. Cost about $100,000. E. T. Archer & Co., New England Bldg., Kansas City, Mo., consulting engineers.

HUTCHINSON, KAN., is arranging $564,000 for municipal gas distribution system, including central distributing station. H. P. Hertz, city engineer.

WYNNEWOOD, OKLA., contracted Fairbanks, Morse & Co., Chicago, Ill., for diesel-generator and equipment for municipal plant, at $63,227. V. V. Long & Co., Colcord Bldg., Oklahoma City, Okla., consulting engineer.

BILLINGS, MONT., plans electric pumping plant for water supply system. Board of Yellowstone County Commissioners, Billings, in charge. $57,300 has been authorized.

AMERICAN LIBERTY PIPE LINE CO., First National Bank Bldg., Dallas., Tex., plans 8-in. welded-steel pipe-line from Rusk, East Texas oil field district, to Conroe, Tex., about 115 miles, for crude oil transmission. Three large pumping plants will be constructed along the route. Project will cost about $1,000,000. Apparently installation will be made by Fredell Construction Co., Houston, Tex. Dudley S. Golding, president of American Liberty Co., in charge.

GULF PIPE LINE CO., Gulf Bldg., Houston, Tex., an interest of Gulf Refining Co., Pittsburgh, Pa., plans welded-steel pipe-line from Hendrick oil area, Winkler County, Tex., to Hubbs oil district, Lea County, N. M., about 65 miles, for crude oil service. Cost over $700,000 with pumping stations. Also planning construction of 6-in. welded-steel line from fields at Rodessa, La., to Mooringsport, La., about 18 miles, to cost over $100,000.

HOUSTON, TEX., is planning improvements in water supply system in 1936 to cost about $935,000. $100,000 for main waterworks pumping station, including electric pumps and auxiliary equipment. Water storage facilities, including steel tanks, to cost about $350,000. Pipe lines in city will represent about $300,000.

HUMBLE PIPE LINE CO., Houston, Tex., plans for 8-in. welded-steel pipe-line from East Texas oil field to Baytown, Tex., via Hearne and Groesbeck, for mixture of butane gas and gasoline for polymerization process at refinery of Humble Oil & Refining Co., Baytown. Booster stations will be built along route. Cost approximately $1,000,000.

HORLOCK ICE INDUSTRIES, INC., 902 Hogan St., Houston, Tex., R. E. Horlock, president, has acquired ice plant at La Porte, near Houston, formerly operated by Houston Lighting & Power Co., and will instal additional equipment.

SALINAS VALLEY ICE CO., Salinas, Calif., plans ice-manufacturing plant on Griffin St., for initial capacity of about 120 tons daily. Cost about $100,000, with machinery. Ralph Myers is general manager.

SAN JOSE (CALIF.) ICE & COLD STORAGE CO. plans rebuilding of portion of ice plant, recently destroyed by fire. Loss about $70,000.

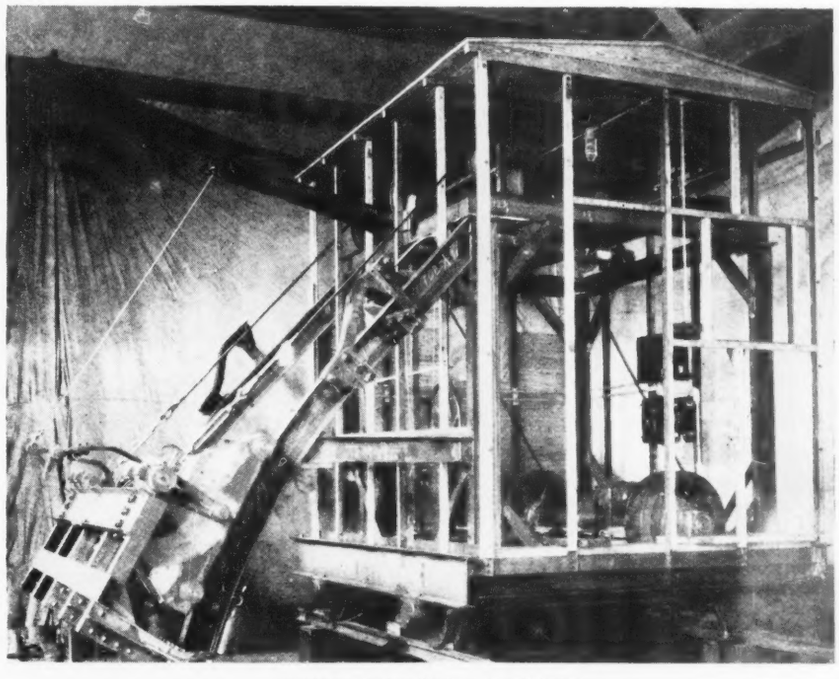
VALE, ORE., plans municipal steam distributing system in downtown district for central heating. Cost about $70,000, $46,000 will be provided by bond issue, remainder through Federal aid.

Foreign

OTTAWA, CAN., Board of Control will soon take bids for three large turbine-driven pumping units, with accessory equipment, to replace reciprocating pumps at municipal waterworks. Cost about $60,000. W. E. MacDonald, City Hall, city engineer.

GREAT LAKES POWER CO., LTD., Saulte Ste. Marie, Ont., is considering hydro-electric plant on Montreal River, vicinity of Michipicoten, Ont., mining district. Project includes dam, generating station with initial capacity over 35,000 kw., transmission lines to mining area and substation. Project will cost upward of $850,000.

DELTA MUNICIPALITY, B. C., has exchanged 25-year-old waterworks pumps for two electrical centrifugal units, made by Pumps and Power, Limited, of Vancouver, which have capacity of 720 g.p.m. each.



CHICAGO RAKES BY POWER

Lockport Hydro Plant's two 8,500-hp. Kaplan turbines use water from the Chicago Sanitary District Canal, hence intake racks become loaded with an unusually large amount of every kind of debris. This S. Morgan Smith power-operated trash rake solves the problem

CHAMELEON . . .

A peacock doesn't impress me nearly as much as a chameleon, because the peacock uses his fancy colors only for show, while the chameleon uses his so he *won't be noticed.* His whole aim in life is to get the result he wants without making his aim so obvious that everybody anticipates him. He's got one great talent, the ability to get where he wants to be without gaudy words or colors, to get what he wants without blowing about it.

These days, with business picking up all along the line, I think some of us would do well to remember the chameleon. We've been asking for improvements, for a new this or that, always to be met with the reply, "We haven't the money." But we've always asked as engineers—acted like one-color chameleons.

So let's change color. Let's try being salesmen instead, and sell our ideas for betterment to the management. That's another color, and may be more successful in getting us what we want, in earning for us good solid respect instead of the realization that we're one-track men, using any color we have just for show.

I'm reminded of the store manager who one day was told that he was all through. To the executives he put the question, "Why?" Their answer was: "Because you haven't kept up with the times." They listed several things he might have suggested to keep up. "But," said he, "I thought of all those things long ago." "Well," they said, "You didn't say anything to us about it, so how could we know?"

He had only one color—he couldn't sell an idea. He was afraid that he couldn't get it across, or had had several earlier ideas turned down, and as a consequence just stopped advancing ideas at all.

Of course the management is to blame for not being more receptive to what he had to say, whether good or bad, but he is just as much to blame because he quit trying. There's an old saying that given time, water will wear away even stone.

Business is better. Instead of the former timidity, many executives are now willing to invest money where they can see a good chance of return. It's your job and mine to pick out the best examples we can muster, and advance those, picking first the ones that will pay for themselves within three or four years. Here's a chance to make 25% or more, right in our own backyards. That's a lot better than money will do anywhere else—even bonds today are hard to get that pay anything over 4 or 5%.

But to get it across to management, we've got to sell, use another of our colors to get the result we want. And when we get it, we'll have helped ourselves by saving company money. We'll not only have had good ideas, but we'll have gotten credit for them.

George Edwards

GEORGE EDWARDS
Engineer